# CHAPTER X

## FIRE PROTECTION

1. COVERAGE. These criteria shall be applied in the planning and design of fire protection for DOE facilities. Additional criteria for specific types of facilities are contained in other chapters of these general design criteria beginning with Chapter XVI.

2. CODES, STANDARDS, AND GUIDES. In addition to the basic building codes identified in paragraph 3a in Chapter I of this Order, the latest editions of the codes, standards, and guides listed below shall also be followed.

    a. Department of Labor (DOL) Occupational Safety and Health Standards (29 CFR Part 1910) promulgated under P.L.91-596, "Occupational Safety and Health Act" (OSHA) of 1970, as amended.

    b. National Fire Protection Association (NFPA), "National Fire Codes."

    c. Underwriters Laboratories (UL), Standards and "Product Directories."

    d. Factory Mutual (FM), "Approval Guide," and FM "Loss Prevention Data."

    e. DOE/EV-0043, "Standard on Fire Protection for Portable Structures," of 8-79.

    f. DARCOM 385-100, "Safety Manual, "U.S. Army Materiel Development and Readiness Command.

    g. WASH 1245-1, "Standard for Fire Protection of AEC Electronic Computer/ Data Processing Systems," of 7-73.

3. DOE DIRECTIVES. Other DOE directives to be followed in planning and design for fire protection include the latest editions of and changes to:

    a. DOE 5480.1A ENVIRONMENTAL PROTECTION, SAFETY, AND HEALTH PROTECTION PROGRAM FOR DOE OPERATIONS, of 8-13-81, Chapters I and VII.

    b. DOE 5481.1A, SAFETY ANALYSIS AND REVIEW SYSTEM, of 8-13-81

    c. DOE 5700.6A, QUALITY ASSURANCE, of 8-13-81.

4. FIRE PROTECTION OBJECTIVES. As identified in Chapter VII, "Fire Protection," of DOE 5480.1A, the objectives of the Department's fire protection program are that:

a. No threats to public health or welfare will result from fire.

b. There are no undue hazards from fire to DOE or contractor employees utilizing DOE facilities.

c. Vital Department of Energy programs will not suffer unacceptable delays as a result of fire.

d. Property damage will be held to manageable levels.

5. IMPROVED RISK CONCEPT.

a. Chapter VII, "Fire Protection," of DOE 5480.1A, establishes requirements for an "improved risk" level of fire protection sufficient to attain the objectives listed in paragraph 4, above. As stated in that Chapter VII, "a higher standard of protection may be justified in certain instances for the purpose of national security, program continuity, or protection of the public."

b. As defined in Chapter VII, of DOE 5480.1A, the term, "improved risk," has the same meaning and intent as is commonly understood when this term or the term, "highly protected risk," is used in the insurance industry. The term involves the use and application of judgment and thus does not lend itself to a precise, fixed definition applicable in all locations and situations. Generally, an improved risk property is one that would qualify for complete insurance coverage by the Factory Mutual System, the Industrial Risk Insurers, and other industrial insurance companies that limit their insurance underwriting to the best protected class of industrial risk. Improved risk protection requires compliance with the fire protection and loss prevention standards identified in Chapter I, "Environmental Protection, Safety, and Health Protection Standards," of DOE 5480.1A. This term also implies that the judgment of qualified fire protection engineers is used to obtain the highest economically-justifiable level of industrial loss prevention.

c. The most evident characteristic of an improved risk level of fire protection is the existence of reliable, automatic fire suppression systems (such as automatic sprinkler, Halon, or other systems), for facilities of combustible construction or content.

d. Essential elements of a program complying with the improved risk concept and the means considered acceptable for complying with the improved risk objectives are identified in Chapter VII, of DOE 5480.1A. General design criteria for those that are specifically applicable to the planning and design of DOE facilities are included below:

(1) DOE facilities shall be designed with respect to exits and fire protection features in accordance with the NFPA 101, "Life Safety Code;" and with specific requirements of Title 29, Code of Federal Regulations, Part 1910, "Occupational Safety and Health Standards."

Where partial compliance, or noncompliance, with some of the code provisions may be necessary for reasons of public safety that are unique to the Department's facilities and operating requirements, as in the case of some containment structures, additional protective features shall be provided as necessary to assure the life safety of facility occupants.

(2) To limit the potential for fast-spreading fires and generation of toxic or other harmful products of combustion:

(a) Interior finish materials, including acoustical materials and exposed wall or roof insulating materials, shall have Underwriters Laboratories (UL) flame spread ratings of 25 or less, and fuel contributed and smoke developed ratings of 50 or less. Specific application exceptions may be made by the DOE fire protection authority having jurisdiction, provided appropriate consideration is given to variation in required flame spread ratings in NFPA 101 depending upon the occupancy and inclusion of automatic sprinkler protection.

(b) Special attention shall be given to selection and use of materials of unusual fire characteristics.

1 Materials such as exposed foamed plastics, other highly combustible plastics, and materials developing large quantities of toxic or other harmful products of combustion, shall not be used for interior finish or other interior applications without the approval of the DOE fire protection authority having jurisdiction. In any use of such materials, severe restrictions shall be placed on material quantities and their location.

2 The use of foamed plastics is generally acceptable when part of a UL listed or Factory Mutual (FM) approved assembly, or part of UL listed or FM approved "sandwich" wall construction which has passed the "corner test" without sprinkler protection. However, such components should not be used in areas where equipment or operations are especially susceptible to damage or other adverse effects from smoke or other products of combustion. Selection and application of such components shall be in accordance with FM recommendations as contained in FM Loss Prevention Data Sheet 1-57, "Rigid Foamed Polyurethane and Polyisocyanurate for Construction," or as otherwise approved by the DOE fire protection authority having jurisdiction.

(c) Where interior floor coverings are provided, they shall conform to NFPA 101 requirements, as a minimum. Interior floor finish includes coverings which may be applied over a normal finished floor. As defined in Section 6.5 of NFPA 101, a Class I interior floor finish is that which will satisfactorily withstand a minimum critical radiant flux of 0.45 watts per square centimeter. A Class II interior floor finish is that which will satisfactorily withstand a minimum critical radiant flux of 0.22 watts per square centimeter. The "Standard Method of Test for Critical Radiant Flux of Floor Covering Systems Using a Radiant Heat Source," NFPA 253 (ASTM E-648-78) shall be utilized to determine the critical radiant flush. For DOE facilities, floor coverings judged to present an unusual hazard (generally excludes such traditional types as wood, vinyl, linoleum, and other resilient floor coverings) shall comply with the following criteria:

1 All carpet type floor coverings used in rooms and other enclosed spaces shall comply with the Federal Flammability (FF) 1-70 "pill test." Since 1971, all carpet manufactured for sale in the United States is required by Federal law to comply with the FF 1-70 pill test.

2 Materials, including carpet type floor coverings, used on floors of exit access corridors and enclosed exits in hospitals and other health care facilities shall be Class I. Where automatic sprinkler systems are installed, this requirement for Class I interior floor finish may be reduced to Class II.

3 Materials, including carpet type floor coverings, used on floors of exit access corridors and enclosed exits in other facilities shall be Class II. Where automatic sprinkler systems are installed, Class II rated floor coverings are not required. Coverings complying with the FF 1-70 pill test may be used.

(d) Hazardous materials, such as flammable liquids and explosive materials, shall be severely restricted in quantity, suitably labeled, compartmentalized, and handled in accordance with all applicable codes and standards. Special protection features, commensurate with the hazards, shall be provided.

(3) At a minimum, facility containment systems, including filters and ventilation systems, shall be designed to preclude offsite release of hazardous amounts of toxic materials under maximum credible fire loss conditions. As defined in Chapter VII, of DOE 5480.1A, "maximum credible fire loss" is the maximum loss that could occur from a combination of events resulting from a single fire. Any installed fire protection systems (e.g., automatic fire suppression systems) are assumed to function as designed. The effect of emergency response (i.e., manual firefighting actions) is generally omitted except for post fire actions. See Chapter VII of DOE 5480.1A for full definition.

(4) Natural or artificial means shall be provided to control liquid runoff so that contaminated or polluting liquids will not escape from the site, including potentially contaminated or polluted water resulting from firefighting actions.

(5) Whenever possible, DOE facilities shall be of fire-resistive or non-combustible construction, and with adequate separation of particularly hazardous operations. The effect of increased wall, roof, or floor insulation for energy conservation, on the fire ratings of DOE facilities, shall be evaluated.

(6) Vital areas that can be directly damaged in the event of a single fire shall be protected by physical means, such as isolation of areas, firewalls, firedoors, draft barriers, and so forth.

(7) To control or adequately limit both vertical and horizontal fire-spread potentials, enclosures of adequate fire-resistive construction shall be provided for stairways, elevators, and ducts. Suitable automatic or manual features such as selfclosing doors, dampers, draft stops, and water curtains shall be utilized when appropriate or required.

(8) Protection shall be provided for the usual hazards, and for special hazards, by isolation, segregation, explosion suppression, and use of automatic fire suppression systems. Features such as relief valves, filters, roof hatches, scuppers, blast walls, and so forth shall also be utilized as applicable for controlling or limiting damage potentials from all hazards that may be anticipated to result from a fire emergency.

(9) Adequate and reliable fire protection water supplies and distribution systems, adequate and properly located hydrants, interior standpipes, and other features shall be provided to facilitate efficient and effective firefighting operations.

(10) Design direction and review of plans and specifications for DOE facilities by qualified fire protection engineers are important to assure the adequacy of fire risk evaluations and protection systems and protective features to meet improved risk objectives and to satisfy specific requirements for each facility. See paragraph 3b, "Health, Safety, and Fire Protection," in Chapter I of this Order, for additional criteria.

e. A higher standard of protection, than the "improved risk" level, may be required for the purposes of program and operating continuity, protection of the public, or national security (i.e., those aspects of national security as referred to in the Atomic Energy Act or 1954 that could be affected adversely by fire, explosion, or other catastrophies). See

Chapter VII of DOE 5480.1A, for criteria that have been established to meet the objective that vital DOE programs will not suffer unacceptable delays as a result of fire, under the "improved risk" concept.

6. FIRE PROTECTION METHODS.

a. Fire protection systems and features for the Department's facilities shall normally consist of combinations of:

(1) Automatic fire suppression systems (alternately termed, "automatic fire extinguishing systems") which include water sprinkler, dry chemical, Halon, or inert gas systems;

(2) Area separation or containment with suitable-rated firewalls and firedoors;

(3) Draft barriers;

(4) Automatic closure devices for openings;

(5) Automatic monitoring of facility and equipment process systems and equipment where fire or explosion hazards exist;

(6) Automatic monitoring of fire protection systems and equipment;

(7) Suitable physical separation of buildings and other facilities;

(8) Automatic fire detection systems;

(9) Water supplies and other systems and equipment for manual fire-fighting; and

(10) Fire Departments. Note that manual firefighting response serves as a backup protection element in achieving fire protection objectives.

b. A level of protection exceeding the "improved risk" level will be necessary for facilities vital to DOE mission accomplishment where large or unusual fire potential exists, there are special life-safety hazards, or the fire consequences may include radioactive contamination of the site or public environment. Such improved protection will generally include such elements as special precautions for preventing fires, multiple types of fire suppresion systems, rapid detection of incipient fires, increased fire ratings of construction materials, rapid-response fire departments, and other special fire prevention and protection features and controls.

7. MAXIMUM POSSIBLE FIRE LOSS CRITERIA.

a. The "maximum possible fire loss" shall be used as a basis for determining the need to provide automatic fire suppression systems, and for additional fire protection systems and features. As used herein "maximum possible fire loss" (synonomous with "maximum possible property loss," as used in Chapter VII, of DOE 5480.1A) means the estimated maximum dollar loss in a single fire area, assuming the absence (or failure) of both automatic and manual fire extinguishing actions, plus related losses incurred in other areas of the facility and losses incurred as a result of operating or program mission interruptions and delays where such losses can be estimated. Estimates of damage to the facility and its contents shall include restoration or replacement costs less salvage value; plus the costs for cleanup, including decontamination where applicable.

b. Criterion I. Whenever the maximum possible fire loss exceeds $1 million, automatic fire suppression systems shall be provided.

c. Criterion II. The need for automatic fire suppression systems shall be evaluated, on a case-by-case basis, when the maximum possible fire loss is below the $1 million level.

(1) The $1 million level cannot be an exact dividing line, and there will be situations where automatic fire suppression systems may be needed or warranted, where the maximum possible fire loss is below this level.

(2) Some examples of situations where automatic fire suppression systems may be needed, or may be warranted, for maximum possible fire losses in the range of $250,000 - $1 million (and even less than $250,000 in some cases) are described below:

(a) Vital facilities may require automatic fire suppression systems without regard to dollar-loss potential. As examples, such systems may be needed, or warranted, for low-value or temporary storage facilities where they contain critical or long procurement-time construction items or for protection of a temporary-use trailer as a control center for a vital one-time activity. Particularly high public visibility or sensitivity may also be justification for providing such systems for the protection of low-value facilities.

(b) System costs may be relatively high in relation to value protected but systems may still be warranted, as in the case of cooling towers of combustible construction or electric power transformers with combustible content. Increased damage from fire, in the absence of automatic suppression systems, could result in extended shut-down of the facilities they serve.

(c) A facility used for storage of lumber or paint may, in itself, be of low value or importance but may be easily protected by extending automatic sprinkler systems from an adjacent, protected facility at a low incremental cost.

(d) Temporary buildings used by construction contractors may warrant the provision of automatic fire suppression systems when they must be located adjacent to more important facilities.

(e) Even though it may be determined that automatic fire suppression systems are not required initially, their provision in the initial facility construction may still be warranted when conditions are extrapolated to the future. For example, a storage facility and its content may be of low value initially, but projected changes in type or quantity of content, or content value (e.g., escalated value in future years) may indicate the need to provide an automatic fire suppression system in the near future. Similarly, increases in combustible loadings in office facilities, and changes to higher-hazard occupancies and activities in laboratory facilities, can often be anticipated from prior experience. The initial provision of automatic suppression systems, or the provision of basic built-in features (e.g., piping mains, risers, headers, valves) for later system extensions, can often be warranted from a minimum life cycle costing standpoint. Without such provisions, a desired future facility conversion to a high hazard occupancy may be difficult and in some cases, prohibited.

d. Criterion III. In general, provision of automatic fire suppression systems is not required if all of the following conditions are satisfied:

(1) The maximum possible fire loss is less than $250,000;

(2) There is no hazard to human life;

(3) Offsite contamination or pollution will not exceed applicable Federal standards;

(4) Adequate separation from other facilities is provided; and,

(5) Important operations or program missions will not suffer unacceptable delays as a result of fire (see Chapter VII of DOE 5480.1A for qualification criteria).

e. Criterion IV. Whenever the maximum possible fire loss exceeds $25 million, efforts shall be made to reduce the maximum loss potential to as near this level as can be reasonably achieved, by such means as additional area subdivision with suitable fire-rated walls. If the maximum possible fire loss still exceeds $25 million, suitable redundant fire protection systems, or methods, shall be provided, with the goal of limiting dollar loss as a result of fire in a single fire area, even in the event of failure of the primary automatic fire suppression system, to no greater than $25 million. In no case shall the maximum loss potential exceed the $75 million loss limit established in Chapter VII of DOE 5480.1A.

(1) Maximum possible fire losses in excess of $25 million are of serious concern.

(2) Redundant fire protection systems may include such facility provisions as dual sprinkler system water supplies, dual piping risers, valving systems, and so forth, such that adequate redundancy in water supply to the sprinkler heads is provided to cover maintenance or emergency outages of either of the water supply systems; or, may include multiple types of automatic fire suppression systems (e.g., water sprinklers and Halon).

(3) Portable fire extinguishers, interior fire hose systems, or interior fire detection and alarm systems do not, in themselves, constitute redundant fire protection systems for purposes of these general design criteria.

(4) Response capability of onsite fire departments will usually be the principal method of redundant fire protection for most DOE facilities, but quick-action (automatic) redundant protection systems may be needed to meet or exceed improved risk levels of protection for some facilities.

(5) There will be some DOE sites or facilities where reliance is being placed on local (e.g., city or county) fire department response capability. A realistic appraisal of fire department response capability, considering the following factors, is an important element in the planning for fire emergencies and satisfying the "improved risk" protection objectives:

(a) Location of fire station(s) with respect to the facility to be protected;

(b) Staffing of stations (e.g. continously is "on-call" volunteer);

(c) Types and amounts of firefighting equipment available;

(d) Method(s) of fire department Modification; and

(e) Degree of commitment that fire department(s) can or will make to respond to fire emergencies in DOE facilities. This factor should be considered of particular importance.

f. Criterion V. The need for redundant fire protection systems or methods, or for supplementing existing redundant fire protection capability, shall be evaluated on a case-by-case basis when the maximum fire loss potential is below the $25 million level.

(1) The $25 million level cannot be an exact dividing line, and there will be situations where redundant fire protection provisions may be needed, or warranted where the maximum possible fire loss is below this level. Certainly, where there is adequate, existing fire department response capability this method of providing redundant fire protection would be used, without regard to fire loss potential. However, depending upon the type of facility, hazards involved in the operation, operating and program-mission impact of interruption and delays from fire emergencies, and other conditions, additional redundant fire protection provisions may be needed to meet or exceed improved risk levels of protection.

(2) For other facilities where adequate fire department response capability does not exist, or cannot be economically provided, other forms of redundant fire protection may also be needed, to meet or exceed the improved risk levels of protection under similar conditions as cited in (1) above.

8. PLANNING AND DESIGN.

a. General Planning Criteria.

(1) Where the restrictions of loss potentials defined in paragraph 7e above do not impose more severe area limitations, and except, as may be specified for particular facilities in other chapters of this order (beginning with Chapter XVI), limitations regarding floor areas, type of construction, height, and so forth, shall conform to applicable requirements of the appropriate building code (e.g., Uniform Building Code or Standard Building Code).

(2) Due to high equipment values and susceptibility to fire damage, electronic data processing equipment rooms shall be protected by automatic sprinklers and/or other acceptable automatic fire suppression systems as identified in WASH 1245-1, "Standard for Fire Protection of AEC Electronic Computer/Data Processing Equipment," and in NFPA 75, "Standard for the Protection of Electronic Computer/Data Processing Equipment;" and as approved by the cognizant DOE fire protection authority. For additional fire protection requirements, see WASH 1245-1 and NFPA 75. The maximum electronic computer/data processing equipment value in any one fire area shall not exceed $50 million. Where area division is necessary to conform to the $50 million limit, a four-hour fire resistive wall is required.

(3) Separation of fire areas within buildings for purposes other than the maximum possible fire loss criteria shall be accomplished by the use of firewalls with resistance ratings conforming to the requirements of the appropriate building codes, or NFPA codes, for special occupancies. Where division is required to conform to the $75 million maximum fire loss criteria, four-hour fire-rated walls shall be provided.

b. Interior Fire Protection.

(1) Automatic Sprinkler Systems. Sprinkler protection shall be provided in accordance with the following criteria:

(a) Systems shall normally be of the wet pipe type, designed and installed in accordance with the pipe schedule rules for "ordinary design" as defined in NFPA 13, "Standard for the Installation of Sprinkler Systems," except that other pipe sizing and spacing may be permitted when the design is hydraulically vertified in accordance with the procedures in NFPA 13. For seismic design criteria and protection features, see Section 3-10, "Protection of Piping," in NFPA 13.

(b) In unheated areas or other areas subject to freezing temperatures, dry-pipe or preaction systems shall be provided. Where the unheated area is small, it may be preferable to install an antifreeze system or small dry-pipe system supplied from a regular wet-pipe system in the main heated area.

(c) In areas especially susceptible to water damage or where it is required that an alarm be provided more quickly than from sprinkler actuation alone, an independent detection and alarm system may be provided. An acceptable alternative is the provision of a preaction type of automatic sprinkler system, arranged to provide alarm at the time of detection. Since the preaction systems are more expensive than normal systems, their application should be based upon a careful analysis of the fire protection requirements.

(d) Automatic sprinkler systems may be used in areas presenting radiation or criticality risk, but require special precautions for handling contaminated water runoff and avoiding potential water induced criticality. Self-restoring sprinkler systems, such as the on-off multicycle system or systems using individual on-off sprinkler heads, may be utilized when a system with automatic shutoff and self-restoring features are necessary. The on-off sprinkler heads that are specified shall be only those proven reliable in addition to being Underwriters Laboratories' (UL) listed. This system application is normally limited to areas with high criticality or radiation contamination hazards where personnel may be unable to enter an area during or soon after a fire and where water runoff must be limited to reduce radiation contamination spread; or to areas where the total volume of water available for fire protection is limited. Since the self-restoring systems are more expensive than normal systems, their application should be based upon a careful analysis of the fire protection requirements.

(e) Sprinkler systems, including deluge, fog, foam-water, or exposure spray protection, designed in accordance with respective requirements of NFPA 13, 15, and 16, may be required for large areas, special hazard situations, or where water supplies are marginal. Special design requirements are needed for cooling towers, large power transformers, high-piled stock, and areas subject to flash fires as specified in the applicable NFPA National Fire Codes.

(2) Other Automatic Fire Suppression Systems. For some occupancies, sprinkler systems may not be suitable and other fire suppression systems may be required. Due to expense and limited capacity, they shall be restricted to small areas of high value or hazard. Normally, they will supplement, not replace, a sprinkler system. When they are provided in lieu of a sprinkler system, that protected area shall be separated from the sprinklered areas by fire-rated partitions, and a system for review and control of occupancy and construction changes shall be maintained. Other types of automatic fire suppression systems include:

(a) Dry chemical (NFPA 17)--normally applied in flammable liquid, or combustible metals (e.g., sodium) situations where water is unsuitable or hazardous.

(b) Carbon dioxide (NFPA 12) and Halon 1301 (NFPA 12A) or Halon 1211 (NFPA 12B)--normally applied in electrical or flammable liquid areas. Halon 1301 is preferable when occupants may be present during discharge of the extinguishing system.

(c) Low expansion foam (NFPA 11) and high expansion foam (NFPA 11A)--low expansion foam is generally limited to special flammable liquid applications. High expansion foam is suitable for most ordinary fires.

(3) Small Hose Stations.

(a) Interior fire hose stations are generally not required in sprinklered buildings. However, the need for such hose stations, in either sprinklered or unsprinklered buildings, shall be determined by the DOE fire protection authority having jurisdiction, based on the safety analysis. Where provided, interior hose stations shall conform to NFPA 14 requirements.

(b) Hose racks in corridors six feet wide or less, shall be recessed.

(4) Interior Standpipe Systems.

(a) In multistory buildings, interior standpipes shall conform to NFPA 14, "Standpipe and Hose Systems." Combined standpipe systems, serving outlets for fire department use and outlets for automatic sprinkler systems, shall also conform to NFPA 13 requirements.

(b) Standpipes shall be provided in large-area buildings where it would be difficult for the fire department to lay hose lines from outside hydrants, or in containment structures (e.g., for radiation containment) where the openings (or penetrations) necessary to apply exterior hose lines cannot be tolerated.

(5) Suppression System Alarms and Controls.

(a) All automatic fire suppression systems shall be provided with supervisory and alarm systems notifying the emergency control group of the actuation or impairment of the system. Supply valves shall be capable of being locked open.

(b) Water extinguishing systems shall have shut-off controls accessible from outside of the protected area. Such valves shall be capable of being locked open.

(6) Automatic Fire Detection and Alarm Systems.

(a) Automatic fire detection and alarm systems may be installed to provide earlier alarm than provided by automatic suppression systems to permit prompt reaction or rapid escape of personnel from hazardous areas. They shall not be installed in lieu of an automatic fire suppression system for general facility protection except as permitted in paragraph (6)(c), below.

(b) Automatic fire detection and alarm systems may be used to supplement suppression systems in areas such as computer facilities, where prompt early warning may result in effective manual actions prior to the activation of the automatic systems.

(c) Automatic fire detection and alarm systems may be used in lieu of automatic fire suppression systems, but only when all of the following conditions are satisified:

1 The maximum possible fire loss does not exceed $1 million;

2 Automatic fire suppression systems are not needed to prevent radioactive contamination of the plant and public environment or pollution exceeding applicable Federal standards;

3 Loss of use of the affected facility will not seriously impair operating or program-mission continuity or the functions of other facilities;

4 Automatic fire suppression systems of a size or type to cope with the hazard are not available, or are not economically feasible, and effective manual firefighting response can be assured; and,

5 The hazard to life is not increased thereby.

(d) Automatic fire detection systems shall consist of UL-listed or FM-approved components placed in accordance with the results of smoke tests or other tests in each facility to assure their proper operation and prompt detection of fires. When location of detectors cannot be determined by test, experienced engineering judgment shall be utilized with sufficient flexibility built into the system to allow for future relocation, or extension of detector coverage.

(7) Portable Fire Extinguishers.

(a) Portable fire extinguishers shall be provided in accordance with NFPA 10 requirements in all facilities whether or not automatic fire suppression is provided. Additional extinguishers for special hazards shall be provided as required from safety analysis. Extinguisher size (weight) should be chosen after consideration of both the size of potential fires and handling capabilities of employees.

(b) Location and mounting shall provide ease of handling, ready identification, accessibility, and protection from damage, in conformance with NFPA 10 requirements. Wall-mounted extinguishers or extinguisher cabinets in corridors six feet wide or less shall be recessed.

c. Exterior Fire Protection Systems and Features. To minimize the fire protection capability at minimum cost the location and layout of all facilities to be protected; fire department connections; fire department access roads and features; and the sizing and location of water supplies, distribution systems, and fire hydrants, shall be carefully integrated.

(1) Facility Accessibility and Separation.

(a) Building orientation, with consideration of other requirements, should permit minimum hose lays from hydrants. Building layout shall allow ready fire department access to standpipe/sprinkler risers, shut-off valves, and pumper connections. The layout should also facilitate access to hazardous areas from the exterior while maintaining any confinement or containment requirements (via air locks or other features). Hazardous areas, such as radioactive or inerted spaces, should be equipped with alarms and interlocks to assure that acccess of emergency personnel does not result in personnel or public hazard.

(b) Roads, gates, fence lines, and plantings shall permit ease of access for fire department operations and accommodate the largest turning radii and operating space requirements of emergency vehicles.

(c) Buildings and other facilities should be sufficiently separated to preclude the spread of fire even in the event of failure of automatic fire suppression systems and ineffective fire department operations. Where adjacent buildings or other facilities cannot be adequately separated, additional protection systems shall be provided, such as exterior sprinklers, barrier walls, and so forth. Required separation shall be determined as a function of building height, fire hazard of facilities to be protected, and adverse environmental conditions. NFPA 80A, "Recommended Practice for Protection of Buildings from Exterior Fire Exposures," shall be followed, at a minimum.

(2) Water Supply.

(a) Minimum practical distances from facilities to water supply sources and distribution mains should be achieved.

(b) Water supply requirements for fire protection shall be based on a fire protection engineering analysis. As a general rule, supplies shall be adequate in pressure and volume to meet the sprinkler demand required by NFPA 13, Tables 2-2.1(A) and 2-2.1(B) for ordinary hazard or better, plus 500 gpm for fire department hose stream. Where reliance is placed on fire department response, either for protection of unsprinklered buildings or where the fire department will serve as redundant (backup) protection, as a general rule the water supply should be adequate to supply at least 0.03 gpm per cubic foot of fire area (volume) at 20 psig residual pressure at the hydrants.

(c) The fire protection water supply shall assure availability regardless of process and domestic water usage. This may be provided by a dedicated fire protection water supply system, multiple or combined supplies with reserve fire capacity, or by connection to an effectively inexhaustible supply (such as in the case of a small plant or facility supplied from a large city distribution system). When storage tanks are used for combined service water and fire water, the minimum volume for fire uses shall be assured by dedicated tank or other physical means, such as a vertical standpipe.

(d) Fire flows shall be available for a period of at least two hours. For very large buildings, buildings with special public or plant hazard potential, multiple building sites, or groups of combustible buildings, a minimum four-hour reserve shall be provided. In the case of facilities with special fire potential problems, the required fire flows and reserves shall be determined from a systems safety analysis for worst-case conditions (e.g., design basis fire), performed in accordance with DOE 5481.1A requirements and guidelines.

(e) For combined systems serving fire protection and other water demands (domestic and/or process), the supply and its distribution system shall be adequately sized to serve the combined peak flow for all uses.

(f) Water tanks for fire protection systems shall conform to requirements of NFPA 22, "Standard for Water Tanks for Private Fire Protection."

(g) Fire pumps shall conform to requirements of NFPA 20, "Standard for the Installation of Centrifugal Fire Pumps."

(3) Water Distribution System.

(a) Where combined fire and domestic/process water systems are provided, the supplies to each building shall be so arranged and valved that the domestic/process systems can be shut down without impairing the supply to the fire systems. Fire supply valves shall be capable of being locked open to assure availability of supply. Combined systems shall include air gaps or other backflow preventers, to preclude the introduction of pollutants which would contaminate the domestic water system and present health hazards.

(b) Whenever feasible, all extinguishing systems should be connected to looped grid or two-way flow distribution systems with sectional valving arranged to facilitate alternate flow paths in the event of breaks, shutdowns for future connections, or system revisions.

(c) New mains should be looped or gridded to existing mains.

(d) Underground fire mains, hydrants, and valves shall conform to the requirements of NFPA 24, "Standard for Outside Protection."

(e) Dedicated fire protection systems shall be planned and designed for the specific purpose, only; and not for any additional industrial or domestic water supply services and usages.

d. Life Safety.

(1) Doors, stairs, corridors, and partitions shall be arranged to facilitate prompt evacuation and contribute the minimum additional fuel and smoke to the building fire environment, and shall conform to applicable requirements of NFPA 101, "Life Safety Code," as a minimum.

(2) Disparate occupancies in a single structure (e.g., offices-manufacturing-warehouse) shall be separated by at least two-hour fire-rated walls. Where specific separation requirements are not covered in the applicable codes, separations of egress routes shall be not less than one-hour fire rated, and separations between disparate fire hazards shall be not less than two-hour fire rated.

(3) Fire-rated separations may be omitted for small areas, such as machine shop tool rooms, shop offices, restroom areas, and so forth, when the overall building protection is not materially reduced thereby.

(4) Design shall provide for smoke abatement and heat removal to assure safe egress of personnel and subsequent firefighting. Exit signs and markings of exit routes shall be visible under emergency conditions with provision of emergency power and lighting for critical safety systems, including full audibility and visibility of local fire alarm signals.

9. QUALITY ASSURANCE. A quality assurance (QA) program shall be developed and implemented for fire protection projects to satisfy the objectives and requirements contained in DOE 5700.6A; and in paragraph 3f (Quality Assurance) in Chapter 1 of this order.

10. INFORMATION REQUIREMENTS FOR SYSTEMS OPERATION. The design contractor, construction contractor, or other designated party shall be required to prepare and deliver to the DOE construction contracting officer (or designee) final, "as-built," schematic and one line system diagrams for fire alarm systems, automatic detection systems, and instrumentation; control and alarm equipment; automatic fire suppression system equipment descriptions and system diagrams; and other engineering information that will be required for operation and maintenance purposes. See paragraph 3m in Chapter I of this order for additional operating and maintenance (O&M) data requirements.

# CHAPTER XI

## AIR POLLUTION CONTROL

1. COVERAGE. These criteria shall be applied for the control and treatment of all airborne and gaseous wastes and subsequent disposal, to assure compliance with the Clean Air Act; the Resource Conservation and Recovery Act; other applicable Federal, State and local laws, regulations, and standards; and applicable Executive directives (Executive Orders and Office of Management and Budget Circulars) as covered in:

   a. DOE 5440.1B, IMPLEMENTATION OF THE NATIONAL ENVIRONMENTAL POLICY ACT, of 5-14-82; and the DOE "Environmental Compliance Guide."

   b. DOE 5480.1A, ENVIRONMENTAL PROTECTION, SAFETY, AND HEALTH PROTECTION PROGRAM FOR DOE OPERATIONS, of 8-13-81.

   c. Federal facilities are required to comply with Federal, State and local standards including emission standards' restrictions on sulfur content of fuel, and other requirements specifically related to the control of air pollutants, established pursuant to the Clean Air Act; as referred to in Executive Order 12088, "Federal Compliance With Pollution Control Standards."

2. CODES, REGULATIONS, STANDARDS, GUIDES, AND DOE DIRECTIVES. In addition to applicable codes, standards, and guides identified in Chapter V, "Mechanical Systems," and in other basic design criteria, Chapters I through XV of this Order, the latest editions of the following regulation, standards, guides and DOE directives shall also be followed for air pollution control:

   a. Environmental Protection Agency (EPA) regulations, standards, and guides.

   b. Federal Construction Council Technical Report No. 57, "Impact of Air Pollution Regulations on Fuel Selection for Federal Facilities," 1970.

   c. DOE 4330.3, FUELS AND ENERGY USE POLICY, of 10-22-80.

   d. DOE 5420.1, ENVIRONMENTAL DEVELOPMENT PLANS, of 8-10-78.

   e. DOE 5440,1B, IMPLEMENTATION OF THE NATIONAL ENVIRONMENTAL POLICY ACT, of 5-14-82; and DOE "Environmental Compliance Guide."

   f. DOE 5480.1A, ENVIRONMENTAL PROTECTION, SAFETY AND HEALTH PROTECTION PROGRAM FOR DOE OPERATIONS, of 8-13-81.

      (1) Chapter I, "Environmental Protection, Safety, and Health Protection Standards." (For specific regulations, standards, and guides applicable to design of pollution control systems and facilities).

(2) Chapter XI, "Requirements for Radiation Protection."

(3) Chapter XII, "Prevention, Control, and Abatement of Environmental Pollution."

g. DOE 5481.1A, SAFETY ANALYSIS AND REVIEW SYSTEM, of 8-13-81.

h. DOE 5700.6A, QUALITY ASSURANCE, of 8-13-81.

3. AIR POLLUTION SOURCES AND CONTROL MEASURES.

a. Planning for Air Pollution Control.

(1) Essential elements of air pollution control planning are analysis of:

(a) potential sources of air pollution;

(b) the characteristics of the pollutants and the feasibility of conversion to usable or saleable products;

(c) alternate methods available for control and treatment of emissions and/or disposal of wastes to the environment.

(2) Priority considerations should be given to the potentials for conservation/recovery of resources, with regard to the Resource Conservation and Recovery Act provisions and implementing regulations in Title 40 of the Code of Federal Regulations, in planning and designing air pollution control systems. The technical and economic feasibility of conversion systems for recovery of useable products should be determined during the planning or early design phase for a project. If such systems prove to be infeasible, then the control of emissions through conventional methods should be vigorously pursued.

(3) Any system which may discharge dust, fumes, gases, or other contaminants to the environment shall be analyzed. Selected pollution control systems shall assure that emissions can be held to the limits prescribed in applicable regulations or standards. Particular attention shall be given to the selection, design, and construction of pollution control systems for combustion-process facilities and incinerators, fume exhaust systems, and volatile product storage facilities. In studying control systems for combustion-process facilities and incinerators the type of fuel to be utilized shall be carefully considered.

(4) Recognition needs to be given to potential multimedia problems. For example, pollutants removed from air emissions, that are not useable, will present waste disposal problems that will need to be resolved. Therefore, in the planning and design of air pollution control systems, the potential adverse environmental impacts on land and water must also be taken into account.

b. Combustion Process Installations.

(1) Draft Auxiliaries. Combustion products from gas, oil, or solid fuel-fired installations shall be discharged to the atmosphere at sufficient height and in such manner as to maximize the dispersion of stack effluent to the surrounding environment. Requirements for dispersion of stack effluent may frequently influence the selection of natural draft rather than mechanical draft methods. Determination of discharge height shall be based on air quality criteria, land use, meteorological, topographical, aesthetic, and operating factors. EPA guidelines to be followed in determining exhaust stack height include:

(a) EPA 600-8-81-009, "Guideline for Fluid Modeling for Atmospheric Diffusion," of 4-81 (NTIS No. PB 81201410);

(b) EPA 450-4-80-023, "Determination of Good Engineering Practice - Stack Height: Technical Support Document for Stack Height Regulation," of 7-71 (NTIS No. PB 82145301); and

(c) EPA 450-4-81-003, "Guideline for Use of Fluid Modeling to Determine Good Engineering Practice - Stack Height," of 7-81 (NITS No. PB 82145327).

(2) Selection of Fuel. General guidance is contained in the Federal Construction Council Technical Report No. 57, "Impact of Air Pollution Regulations on Fuel Selection for Federal Facilities." Fuel selection shall be in accordance with the provisions in DOE 4330.3, FUELS AND ENERGY USE POLICY. Selection from among alternatives shall further be governed by applicable pollution control requirements and shall include an analysis of the capital and operating costs associated with required emission control facilities. Frequently, higher-cost fuels may be justified where they reduce the emission control equipment requirements. In the design for reduction of sulfur emissions, consideration should be given to alternate technologies, such as fluidized bed combustion or the use of scrubbers with high sulfur coal. Also, the use of refuse-derived fuel (RDF) and bio-gas generation by anaerobic decomposition of sewage solids may be viable alternatives. In comparing alternate sulfur-content fuels, evaluation of the fuel heat values and thermal efficiencies of the firing methods is required, since it is the quantity of sulfur emitted for a given heat input that is of more significance, than the sulfur content of the fuel.

(3) Firing Equipment. All combustion process systems shall have fully automatic firing, and installations shall be in accordance with the recommendations of the manufacturer of the firing equipment. Stoker-fired installations shall be designed to provide for over-fire, secondary air jets controlled by a smoke-detecting device. Combustion controls shall be provided for firing equipment regardless of design, capacity, or fuel burned, to maintain proper fuel/air ratio. In design and construction of firing equipment, or equipment conversions, it is important that necessary burning time, temperature, turbulence,

and fuel-air ratio criteria have been met to eliminate hydrocarbon components from the flue gas. Also, provisions for agglomeration of inert particulate matter into larger particles, within the high temperature zone of firing equipment, will permit more efficient operation of gas cleaning equipment.

(4) Flue-Gas-Cleaning Equipment. Flue gas cleaning equipment shall be provided, as required to meet applicable air quality standards and regulations. See paragraph 3d, below.

(5) Emission Detectors. Depending upon firing capacity, continuous emission (opacity) monitors and alarms may be required on combustion process installations fired with coal or residual fuel oil.

(6) Coal and Ash Handling. Systems for storage and handling of coal and ash shall include adequate provisions for preventing the release of significant quantities of dust to the atomosphere. The atmospheric vents on pneumatic ash-handling systems shall be equipped with dust collection devices capable of controlling emissions within the limits of applicable regulations and standards.

(7) Facilities for Testing. Periodic testing of combustion process equipment is essential to verify that such equipment is not exceeding the emission limitations established by applicable regulations and standards. Access openings, platforms, ladders, and so forth, shall be provided where required for such testing.

c. Refuse Disposal Facilities.

(1) Incinerators.

(a) Where incinerators are to be provided for refuse disposal, they shall be designed to burn efficiently with minimum environmental impact, based on best-current technology. Wherever possible, incinerators which have been approved by the State having jurisdiction, for the type of refuse to be incinerated, should be purchased. Where the state does not have an incinerator approval program, the manufacturer should be required to submit, with its quotation, certified test results demonstrating conformance with applicable standards and regulations. See additional design criteria for incinerators in Chapter V of this Order.

(b) Incineration will generally be the best method for disposal of many toxic or other hazardous waste. Incineration of hazardous materials presents a special case, requiring special permits and preoperational testing. See 40 CFR Part 260, et seq, for hazardous waste management regulations and Subpart O, "Incinerators," of Part 265 for incinerator operating requirements. Also see DOE "Environmental Compliance Guide," Volumes I and II for additional guidance in implementing requirements with regard to generation, handling, and disposal of hazardous wastes.

(c) Experience has shown the tendency to operate fire incinerators in excess of the design capacity, resulting in increased atmospheric pollution. This needs to be recognized in the planning, design, and acquisition of incinerator facilities, by providing adequate incinerator capacity and assuring adequate pollution control capabilities, emission control and monitoring features, and firing-rate limit controls. Administrative controls of incinerator operations are additional protective measures that need to be employed.

(d) In the evaluation of incineration vs. alternate refuse disposal methods, consideration shall be given to the use of incinerators as a possible means of energy conservation (waste heat recovery/use), particularly where the larger volumes of waste are being generated. The use of wet process destructors, pulverizers, shredders, and compactors, as alternatives to incineration, should also be considered for disposal of paper wastes. These methods can be utilized for classified paper wastes if such methods, and the ultimate disposition of these wastes, will meet DOE security requirements.

(2) Offsite Disposal. Nearby city, county, or commercial disposal facility capabilities should be investigated and utilized if economically and operationally feasible. Such facilities shall comply with applicable air quality standards and regulations, permit requirements, and for classified disposal, DOE security requirements.

(3) Landfill and Dumping. Solid and liquid wastes not properly disposed of (discharged) into the air or surface water are subject to the provisions of the Resource Conservation and Recovery Act (RCRA) of 1976, as amended, and implementing regulations in 40 CFR 241, et seq. The appropriate State environmental agency or regional EPA office should be consulted when any such wastes will be generated and not incinerated.

d. Gas-Cleaning Equipment and Emission Control Devices. The selection of industrial air-cleaning equipment depends on the type, size, and distribution of the particles to be removed; the quantity of gas to be treated; the concentrations of the aerosol; the temperature of the gas; and the required efficiency of removal. Some of the systems, and their applications are listed below. This is not a complete listing, and other types of systems will include $SO_2$ emission controls (dry scrubbers as well as wet scrubbers), $NO_x$ controls, and so forth. Selection of equipment will need to be based on the physical-chemical characterization of the pollutants emitted and the applicable air pollution regulations that need to be satisfied. The use of modern and innovative control techniques is encouraged.

(1) Settling Chambers are generally satisfactory where particle size is large. They should rarely be considered for any application involving particles less than 60 microns in size.

(2) Inertial and Centrifugal Separators should generally be considered for installations where the removal of particles larger than five to ten microns is desired. They are not recommended for installations where the exit gas loading frequently decreases below that level necessary to achieve effective particulate removal unless used in combination with other types of emission control devices (e.g., electrostatic precipitators). Operating characteristics of separators make them suitable for the control of particulate emissions from stoker-fired boiler units.

(3) Electrostatic Precipitators are generally applicable to installations where removal of particles of one micron or less in size is desirable (e.g., pulverized coal and cyclone-fired boiler units). They should not be used for oil-fired units or systems involving explosive gas streams.

(4) Fabric Filters or Bag Filters have collection efficiencies (almost 100 percent) through a wide range of particle sizes but have not been favored over inertial or electrostatic collectors for boiler plant application because of their higher capital and operating costs and limitations imposed by high gas stream temperatures. Recent design and material improvements, however, have made them a more viable option.

(5) Wet Scrubbers have wide range application in the collection of industrial dusts and mists. Problems associated with corrosion, fouling, and contaminated water and residue disposal should be individually evaluated when wet scrubbers are planned to be used as emission control devices on boiler plants.

e. Storage Facilities for Volatile Liquids. Vapor emission control devices shall be installed on volatile liquid storage facilities as required, to meet applicable standards and regulations. Submerged fill-piping should be provided on new storage tanks. Other requirements that may be imposed by the particular State, regional or local authority having jurisdiction, such as pressurized storage of volatile organics, shall also be satisfied.

f. Other Air Pollution Producing Facilities. Exhaust systems for the disposal of dust, fumes, or gases which are toxic or noxious or may in any manner contribute to the pollution of the environment shall be equipped with appropriate emission control devices (e.g., filters, scrubbers, separators, precipitators, settling chambers, and so forth) to assure emissions within acceptable limits.

g. Operating Manuals and Instructions. An operating manual containing the bases of design, drawings, flow diagrams, control diagrams, and operating instructions, adequate to enable the operators to understand the facility potentialities, limitations, and maintenance needs, shall be provided for all treatment and disposal systems requiring maintenance and operating surveillance. Data on design, installations, and operating features required by applicable standards and regulations of Federal, State, and local authorities, shall be included. Suggested recording forms shall also be included for maintaining all operating records essential for evaluation of performance and costs, both operating and maintenance.

4. QUALITY ASSURANCE. A quality assurance (QA) program shall be developed and implemented for air pollution control projects to satisfy the objectives and requirements contained in DOE 5700.6A and in paragraph 3f, Chapter I of this Order.

5. CONTROL OF POLLUTION DURING CONSTRUCTION. During construction of facilities, provisions need to be made to minimize air pollution and assure compliance with applicable Federal, State, and local laws, standards, and regulations. Requirements for environmental pollution control, including required permits, need to be clearly stated in construction bidding documents and discussed at prebid conferences. The following measures shall be considered in planning for construction and in development of bidding documents:

a. Use of municipal or site facilities for the incineration or disposal of construction refuse. Where disposal facilities are not available, construction refuse shall be disposed of in such a manner as to reasonably minimize environmental pollution.

b. Limiting removal of vegetation, the planting of temporary vegetation, or placing of mulch over cleared areas to maximize dust control.

c. Utilizing methods of restricting dust to tolerable limits on access roads and early paving or placement of base courses on project roads and parking areas.

d. Precautions to avoid grass or brush fires.

e. Precautions against atmospheric contaminants from fuels, chemicals, and lubricants.

## CHAPTER XII

## WATER POLLUTION CONTROL

1. COVERAGE. These criteria shall be applied in the planning and design for the control, treatment, and disposal of all liquid wastes released to the environment, to assure compliance with the Clean Water Act, the Federal Water Pollution Control Act, the Safe Drinking Water Act, and other applicable Federal, State, regional and local laws, regulations and standards, and applicable Executive directives (Executive Orders and Office of Management and Budget circulars) as covered in:

    a. DOE 5440.1B, IMPLEMENTATION OF THE NATIONAL ENVIRONMENTAL POLICY ACT, of 5-14-82; and the DOE "Environmental Compliance Guide."

    b. DOE 5480.1A, ENVIRONMENTAL PROTECTION, SAFETY, AND HEALTH PROTECTION PROGRAM FOR DOE OPERATIONS, of 8-13-81.

    c. Federal facilities are required to comply with regional and State water quality standards established pursuant to the Federal Water Pollution Control Act; as referred to in Executive Order 12088, "Federal Compliance With Pollution Control Standards."

2. CODES, STANDARDS, GUIDES, AND DOE DIRECTIVES. In addition to applicable codes, standards, and guides identified in Chapters I through XVI of this Order, the latest editions of the following regulations, standards, guides and DOE directives shall also be followed in the planning and design for water pollution control:

    a. Title 40 CFR Part 125, "Policies and Procedures for the National Pollutant Discharge Elimination System." (For requirements that permits must be obtained from the Environmental Protection Agency (EPA), or the state if it has established an EPA-approved permitting program, for all discharges of pollutants from point sources into navigable waters.

    b. Standards and guides of the Water Pollution Control Federation, the Conference of State Sanitary Engineers, and the American Society of Civil Engineers pertaining to sewage systems and sewage treatment methods.

    c. Environmental Protection Agency regulations, standards, and guides.

    d. DOE 5420.1, ENVIRONMENTAL DEVELOPMENT PLANS, of 8-10-78.

    e. DOE 5440.1B, IMPLEMENTATION OF THE NATIONAL ENVIRONMENTAL POLICY ACT, of 5-14-82; and DOE "Environmental Compliance Guide."

    f. DOE 5480.1A, ENVIRONMENTAL PROTECTION, SAFETY, AND HEALTH PROTECTION PROGRAM FOR DOE OPERATIONS, of 8-13-81.

(1) Chapter I, "Environmental Protection, Safety and Health Protection Standards," for specific regulations, standards, and guides applicable to design of pollution control systems and facilities.

(2) Chapter XI, "Requirements for Radiation Protection."

(3) Chapter XII, "Prevention, Control, and Abatement of Environmental Pollution."

g. DOE 5481.1A, SAFETY ANALYSIS AND REVIEW SYSTEM, of 8-13-81.

h. DOE 5700.6A, QUALITY ASSURANCE, of 8-13-81.

3. PLANNING. The following should receive early attention in the planning phase in order to provide an overall cost-effective solution to the protection of the aquatic environment and water supply sources, both surface and underground:

a. Alternate Production Flow methods. In the case of new DOE production/manufacturing facilities, there may be alternate production flow methods which may have different effects on the waste stream characteristics. Waste treatment costs, manpower requirements, and so forth should be factored into production method decisions in the planning stage. Water use management principles shall be applied to reduce water consumption (and volume of wastes) whenever technologically feasible.

b. Recycle and/or Recovery of Waste Streams. Zero discharge of pollutants is the Congressional goal expressed in the Federal Water Pollution Control Act. In order to meet Congressional intent, it is necessary to consider recycle/recovery techniques for the entire waste stream or for constituent parts.

c. Alternative Waste Treatment Techniques. In those instances where effluent treatment is required prior to discharge to receiving streams, alternate treatment systems should be evaluated. The Federal Water Pollution Control Act requires "best available" treatment by 1983, as determined by the Environmental Protection Agency (EPA). Factors to be evaluated and negotiated with EPA include capital costs, operating costs, simplicity of facility operations, facility compatibility with site, and sludge generation and disposal.

d. Disposal of Solids Generated During Liquid Effluent Treatment. Since effluent treatment in many cases consists of converting liquid waste into solid waste, careful consideration shall be given to sludge disposal. Sludge toxicity, solubility, and so forth may make ordinary landfill disposal unsuitable. Therefore, techniques such as stabilization, biodegradation or biosphere isolation may be required. Protection of ground and surface water is particularly important in these evaluations and is required pursuant to the Clean Water Act, Safe Drinking Water Act, and the Resource Conservation and Recovery Act.

e. Planning for Waste Treatment Facilities.

(1) Where feasible, the use of municipal sewerage systems maintaining adequate treatment is preferred for the disposal of sanitary sewage and other domestic-type wastes. The requirements of the pretreatment provisions of the Clean Water Act shall be satisfied if industrial sewage will be discharged into a community treatment facility.

(2) Separate systems are strongly recommended for the treatment and disposal of sanitary, industrial, and radioactive wastes. The combination of radioactive waste treatment with other treatment systems shall be avoided where possible and should be considered only in exceptional cases. The introduction of surface drainage water into sewage or other treatment systems is also strongly discouraged.

(3) Land application of primary-treated sanitary sewage waste water should be considered where soil conditions and other conditions at the particular site are determined to be suitable.

(a) Where the land application method is selected, special attention needs to be given to the potentials for pooling of waste water on the ground and waste water runoff. Land application systems need to be carefully designed and operated, to avoid adverse impacts on land and ground water. Provisions should be made for monitoring the ground water to detect changes in water quality. If the spray method of land application is used, provisions should also be made for monitoring air quality impact.

(b) In the planning and design of land application of waste water, consideration shall be given to anaerobic decomposition (and associated volume reduction) of the solid wastes for production of methane gas as an energy source. Recommendations of the EPA shall be followed in selection and use of any land application method.

(4) Topography and location relative to the waste-collecting systems and the effluent disposal point will usually be the governing factors in selecting the site of the waste treatment plant. The intrusion of contaminants to ground and surface waters shall also be considered where such facilities as holdup ponds, lagoons, and so forth are utilized in the treatment process.

(a) Treatment plants and facilities, particularly those which may emit objectionable odors, shall be located as far as practicable from inhabited buildings and thoroughfares. Consideration also shall be given to the direction of prevailing winds.

(b) To the extent feasible, sewage treatment plants shall be located so as to minimize nuisance aspects and unsightliness. However, this should not be interpreted as requiring that such facilities be strictly isolated on the site. Where feasible, and applying good land use principles, they should be located in areas where beneficial use can still be made of the surrounding land. Locations subject to flooding shall be avoided.

(5) Waste treatment facilities shall include laboratory space required for sample testing, analysis, and records maintenance.

(6) An operating manual containing the bases of design, drawings, flow diagrams, control diagrams, and operating instructions, adequate to enable the operators to understand the facility capabilities, limitations, and maintenance needs, shall be provided for all treatment and disposal systems requiring maintenance, and operating surveillance. Data on design, equipment, and operating features required by applicable standards and regulations of Federal, State, and local authorities shall be included. Suggested recording forms shall also be included for maintaining all operating and control records essential for evaluation of performance and costs. Safety instructions (safety manual) should also be provided, for use by operating and maintenance personnel.

4. SANITARY SEWAGE DISPOSAL.

a. Sewer System Layout. The layout of sewage collection systems shall be as simple and direct as possible and consideration shall be given to future expansion needs and maintenance requirements. Preliminary development of the sewer layout should proceed concurrently with other site planning since the collection system will be affected by the siting of buildings other facilities, as well as by the topography and other features of the site.

b. System Design Features.

(1) American Society of Civil Engineers (ASCE) Manual No. 37, "Design and Construction of Sanitary and Storm Sewers," provides excellent guidance for hydraulic design of sewer systems.

(2) All sewerlines shall be located outside of roadways to the extent practicable. Sewerlines shall not be located under buildings or other facilities unless there is no feasible alternative. Sewerlines shall be located at least 10 ft. horizontally from domestic waterlines and from firewater or other waterlines which are connected to the domestic water system and not protected against backflow. However, if the top of the sewerline is at least one foot below the bottom of the waterline, the horizontal separation may be reduced to 6 ft.

(3) At water and sewerline crossings, the sewerline should normally be located at least 2 ft. below the waterline.

(4) Where a gravity flow sewerline must cross above a waterline or is less than 2 ft. below the waterline, the sewerline shall be steel, extra heavy cast iron, or other suitable pressure pipe for a distance of 10 ft. on each side of the waterline. Joints in the sewerline immediately above the waterline should be avoided. Reinforced concrete encasement of existing sewerlines will be permissible as an equivalent. Where a sewer force main from a pumping station crosses a waterline, the sewer main must be at least 2 ft. below the waterline. Where a sanitary or industrial sewerline is located within 50 ft. of a well or a water tunnel shaft, the sewerline shall be constructed of extra heavy cast iron, steel, or other pressure pipe. In pervious soils, it may be necessary to increase this distance. A minimum cover of 2 ft. (or greater for reason of frost, severe superimposed loading, and so forth) shall be provided over sewerlines.

(5) Normally, the quantity of flow of domestic sewage will approximate the rate of domestic water consumption except where ground water infiltration into sewers may be significant. Standard engineering guidelines for various facility occupancies should be used to establish the design loadings.

(6) Special consideration shall be given to the possibility of batch releases into the system due to operation schedules in research or production areas.

(7) In the design of collecting lines serving areas which are likely to be further developed, provisions should be made for approximately 25 percent additional capacity over initial requirements. Such increases in capacity are usually attainable by using the next larger size pipe. In trunk and main outfall lines, oversizing by not more than 25 percent of the average daily flow may be justified. The design capacity of treatment facilities should not exceed known program requirements by more than 20 percent of the average daily flow. Treatment plants and related facilities shall be designed, wherever feasible, so that future expansion and maintenance will be possible without interfering with the operations of existing facilities.

(8) In general, gravity sewerlines shall be laid on sufficient slope to produce velocities of at least 2 ft. per second at average rate of flow. Where doubt exists as to adequate velocities throughout the expected range of flows, a velocity analysis should be made for both peak and average rates of flow.

(9) In the design of collection systems, pumping shall be provided only when economic evaluation indicates lower overall costs than gravity flow.

(10) Trench widths shall be held to the minimum practicable, particularly from the top of the pipe to bottom of the trench, where the sides of the trench should be vertical. Provision of proper bedding is

essential on all sewerlines. Safety measures shall be specified to assure safe working conditions in trenching and installation of pipe.

c. Pipe Materials and Pipe Joints.

(1) The suitabiity of various types of pipe for sanitary sewers depends on soil conditions to be encountered as well as the chemical properties of the sewage. Clay sewer pipe or autoclave-manufactured asbestos-cement pipe in standard commercial sizes may generally be used under all conditions. Concrete, polyvinylchloride (PVC), or other satisfactory competitive-type pipe may be used except where acids or alkalis are present in the soil or in the sewage in such concentrations as to necessitate pipe replacement during the estimated life of the project. Service weight cast iron, steel, reinforced concrete, or asbestos-cement pressure pipe shall be used for force mains, stream crossings, under roads and parking areas, inverted siphons, waterline crossings, or where there is a possibility that system leakage may contaminate nearby water supplies.

(2) Pipe joint materials for gravity lines shall be of the type best suited for the selected type of pipe and to meet local conditions. Portland cement mortar, premolded rubber ring gaskets, and certain plastic and bituminous jointing compounds are satisfactory materials if properly installed and shall generally be used for average conditions. Joints of hot poured bituminous material are effective for resisting infiltration and root penetration and should be specified if such conditions are expected to be serious. Slip-on joint pipe has proven satisfactory, with low installation costs. Careful study shall be made with respect to pipe joint specifications where ground water infiltration of serious proportions can develop.

d. Treatment Facilities. All sewage treatment facilities shall meet, as a minimum, the treatment standards established by the EPA. Standards for specific locations are established on a case-by-case basis by the EPA in consultation with the respective State or regional environmental protection authorities. See Water Pollution Control Federation (WPCF) Manual of Practice MOP/8, "Wastewater Treatment Plant Design" (1977), for design guidance. Where load increases are contemplated, consideration should be given to modular construction rather than oversizing plants, since an oversized plant will seldom operate efficiently at reduced loading. Septic tanks and drainage fields may be used where loads, soil conditions, and local regulations permit. However, modern packaged aeration plants, with land application of the treated waste water, need to be given full consideration. This method will usually provide better environmental protection and reduce ground water contamination.

5. CONTROL OF POLLUTION FROM OTHER SOURCES.

a. Facilities for the storage of oils, fuels, chemicals, or toxic and hazardous materials shall be located or protected so as to prevent the pollution of nearby surface waters and ground water as a result of vessel, rupture, spillage, or other accidental release. Where feasible, contaminated coolant oils should be reclaimed on site and recycled in order to minimize storage and disposal problems.

b. All storage tanks shall be designed and constructed to assure structural integrity. Aboveground tanks, used for the storage of toxic or other hazardous materials, shall be provided with entrapment dikes, catchment areas, or other suitable measures for containment to prevent runoff of contaminants, and to facilitate cleanup of contaminants and minimize groundwater pollution hazards. Underground storage tanks shall be constructed of material(s) protected against corrosion (cathodic protection systems when needed) and with attention given to protect against structural failure and to assure containment integrity. The need for leak monitoring and alarm systems, multiple-wall containment, or other protective measures will be commensurate with the toxic or other hazardous nature of the stored materials and their quantities. Underground tanks shall be buried in suitable soil and properly vented to the atmosphere, including filtration if needed. Storage tanks, aboveground or underground, shall be appropriately anchored, where safety analyses dictate the need. Vent piping, fill and withdrawal piping, and related equipment at grade level above buried tanks shall be adequately posted and protected. The surrounding area shall be diked or provided with other suitable measures for containment of toxic or other hazardous contaminants for potential leaks, spills, or pipe rupture.

c. Measures for the control of pollution from other facility sources include minimizing water sources and use of floor drains in those facilities where process spills or cleanup water would flow into tie-ins to sanitary or storm sewers. These tie-ins could be sources of unwanted infiltration, which may upset sewage treatment facility operations or present sources of unpermited discharges to surface waters, under Clean Water Act restrictions.

d. Suitable measures for groundwater contamination control shall be provided for landfill leachate and coal pile runoff. These are common sources of potential pollution in DOE sites.

6. QUALITY ASSURANCE. A quality assurance (QA) program shall be developed and implemented for water pollution control projects to satisfy the objectives and requirements contained in DOE 5700.6A and in paragraph 3f, Chapter I of this Order.

7. CONTROL OF POLLUTION DURING CONSTRUCTION. During construction of facilities, provisions need to be made to minimize soil erosion, and minimize water pollution, and assure compliance with applicable Federal, State, or local law,

standards and regulations. Site studies are needed to plan and design those measures needed to assure an acceptable degree of pollution and erosion control for the site. Requirements for erosion and pollution control measures, including required permits need to be clearly stated in construction bidding documents and discussed at prebid site conferences. The following measures shall be considered in planning for construction and in development of bidding documents.

a. Minimizing the area and duration of exposure of erodible soils and scheduling construction of roads, streets, parking, and other site development work as soon as practicable. Where finished paving is not practical, consideration should be given to early placement of permanent base or subbase courses. Early paving will not only reduce erosion and pollution but, in many cases, will result in more efficient construction operations.

b. Minimizing soil erosion by providing temporary vegetation or mulch and by establishing permanent vegetation as early as practical.

c. Providing features to retard the rate of runoff, and to trap sediment resulting from construction.

d. Specifying temporary bridges or culverts where fording of streams is objectionable.

e. Providing protection against pollutants, such as chemicals, fuel, lubricants, sewage, and so forth.

f. Scheduling and performing site development work to avoid rainy seasons.

g. Requiring the use of portable chemical toilets or prohibiting the location of sanitary facilities over or adjacent to live streams, wells, or springs.

h. Specifying precautionary measures to avoid grass or brush fires, since burned-over areas are highly vulnerable to erosion.

i. Requiring treatment of soil borrow areas to minimize water pollution from the operation.

# CHAPTER XIII

## ENERGY CONSERVATION AND USE OF RENEWABLE ENERGY SOURCES

1. COVERAGE.

   a. These criteria are particularly oriented to the Department's new buildings and building additions, their operating systems and energy using equipment. They shall be applied in the planning and design of such facilities with the objective of minimizing consumption of nonrenewable energy on a life cycle cost effective basis. Companion use shall be made of energy conservation-related design criteria in Chapters IV, V, and VI of this Order. For purposes of this chapter the term building shall be interpreted as new building and building additions, unless otherwise stated.

   b. The objective of minimizing consumption of nonrenewable energy on a life cycle cost effective basis also shall be applied in the planning and design of building and building systems alteration projects and other energy-using facilities (such as new central utilities plants, utility distribution systems, and exterior lighting systems).

   c. It is also necessary that buildings or other structures acquired by the Department, or by contractors or subcontractors for the Department, are energy efficient. These include preengineered metal buildings, in-plant fabricated modular/relocatable buildings, trailer units, and other buildings that may be acquired. The building envelope thermal transmittance values criteria in paragraph 6b and other applicable energy conservation criteria for mechanical-electrical systems identified in paragraph 6c shall be considered minimum criteria to be applied. These transmittance values criteria shall be reflected, to the maximum extent feasible, in specifications that are developed and applied in such facility acquisitions.

   d. This chapter contains a substantial amount of information that is deemed necessary to assure full recognition within the Department, and by contractors and subcontractors, of the Federal law, Executive order, and Federal regulation requirements as related to energy conservation and use of renewable energy sources in the Department's facilities.

2. FEDERAL LAW, EXECUTIVE ORDERS, REGULATIONS, AND DEPARTMENTAL DIRECTIVES.

   a. Title V of Public Law 95-619, "National Energy Conservation Policy Act," of 11-9-78, which states in part:

      (1) "It is the policy of the United States that the Federal Government has the opportunity and responsibility, with the participation of industry to further develop, demonstrate, and promote the use of

energy conservation, solar heating and cooling, and other renewable energy sources in Federal buildings." (section 542, part 3 Title V.)

(2) "All new Federal buildings shall be life cycle cost effective...." "In the design of new Federal buildings, cost evaluations shall be made on the basis of life cycle cost rather than initial cost." (section 545(b), part 3 Title V.)

(3) "The term 'Federal Building' means any building, structure, or facility which is constructed, renovated, or leased, or purchased in whole or in part for use by the United States, and which includes a heating system, a cooling system, or both." (section 544, part 3 Title V.)

b. Executive Order (E.O.) 12003, "Relating to Energy Policy and Conservation," of 7-20-77, amending E.O. 11912, "Delegations of Authorities Relating to Energy Policy and Conservation," of 4-13-76, which established the 45 percent energy-use reduction goal for new Federal buildings.

c. Subpart C, "Guidelines for Buildings Plans," of 10 CFR part 436, which requires in Section 436.51, "Design Program for New Federal Buildings":

(1) That each Federal agency shall provide in its buildings plan for the metering of building energy use in new Federal buildings; analysis of at least two alternative building designs, at least one of which includes a renewable energy system; and selection of a building design which minimizes total life cycle costs as measured in accordance with subpart A of 10 CFR part 436.

(2) That the design goal for a new Federal building shall be set by building category at the rate of building energy consumption equivalent to a reduction of 45 percent in average energy use per gross square foot of floor area in FY 1985, from the average building energy use per gross square foot of floor area of a representative Federal building of that category in FY 1975.

d. Subpart A, "Methodologies and Procedures for Life Cycle Cost Analyses," of 10 CFR part 436, which establishes a methodology for estimating and comparing the life cycle costs of Federal buildings and for determining life cycle cost-effectiveness. The methodology evaluates the economic consequences of investments in alternative building systems (energy conservation measures including renewable energy systems for existing buildings, and energy-saving building systems including renewable energy systems for new buildings).

e. DOE 4330.3, FUELS AND ENERGY USE POLICY, of 10-22-80, states in part, that "It is the policy of the Department to --- maximize the use of noncritical fuels, such as coal and solar, and minimize the use of the critical fuels, petroleum and natural gas, by discontinuation of the use of natural gas and petroleum in new facilities; --- (by) the increased use of residual (waste) energy; (by) emphasis on the use of new and advanced energy technologies; ---." See DOE 4330.3 for all requirements related to fuels and energy use, including controls on the use of electric resistance space heating in new facilities.

f. DOE 4330.2A, IN-HOUSE ENERGY MANAGEMENT PROGRAM, of 2-16-82, states that "It is the policy of DOE to promote efficient and economical use of energy in all DOE-owned or -leased facilities, including buildings and energy conversion and distribution systems, and DOE-owned or -operated vehicles and equipment implementing an In-House Energy Management Program for DOE," with an objective of "assuring energy efficient design of new facilities."

3. TIMING OF EVALUATIONS AND SELECTIONS OF ENERGY CONSERVATION FEATURES AND ENERGY SUPPLY SOURCES.

a. Integral elements of the facility planning and design process are evaluations and selections of energy conservation features and energy supply sources. To assure that the necessary energy conservation features are included in the overall project requirements, and associated cost are included in the official cost estimate prior to project authorization, evaluations and selections of features on the basis of life cycle cost effectiveness need to be made during:

(1) The conceptual design phase, for line item construction projects proposed for full project authorization in annual budget requests after performance of conceptual design. Where all such energy conservation and energy supply features cannot be identified during the conceptual design phase, suitable allowances will need to be included in the project authorization funding requests to assure the achievement of an energy-efficient facility in the follow-on design phases.

(2) The conceptual design phase, or in preliminary (Title I) or detailed (Title II) design prior to full project authorization for line item construction projects that are to initially receive partial authorization (e.g., for architect-engineer work only, prior to full project authorization).

(3) The planning phase (e.g., conceptual design or other project planning), or in preliminary or detailed design prior to full project authorization, for contingency-type projects.

(4) The planning phase, or in preliminary or detailed design prior to full project authorization, for general plant projects.

b. Evaluations of energy conservation and supply alternatives will usually be required through the preliminary design and into the final design phase. These evaluations usually include new or updated life cycle cost analyses, and often result in different systems being selected than originally conceptualized. Therefore, careful planning is required during the conceptual phase to ensure that the conceptual cost estimates provide contingencies to cover the changes in selected systems that are likely to occur during the design process.

c. Fuels and energy selections shall be in conformance with DOE 4330.3, FUELS AND ENERGY USE POLICY, of 10-22-80.

4. LIFE CYCLE COST ANALYSES.

a. Life cycle costing involves a systematic comparison of investment decisions using a discount factor to calculate the present worth of future benefits and costs. Prescribed "Methodology and Procedures for Life Cycle Cost Analyses," promulgated by the Assistant Secretary for Conservation and Renewable Energy, as a final rule in the Federal Register of 1-23-80 (subpart A to 10 CFR part 436), as amended, shall be utilized.

b. The latest edition of the "Life Cycle Costing Manual for Federal Energy Management Programs," NBS Handbook 135, shall be used, as supplemented with additional DOE-specific requirements developed and promulgated by the In-House Energy Management Branch, Office of Project and Facilities Management, Directorate of Administration, at DOE Headquarters. Single copies of the Handbook may be obtained from the Department's Technical Information Center, P.O. Box 62, Oak Ridge, TN, 37830.

5. USE OF COMPUTER OR OTHER ENERGY ANALYSIS TECHNIQUES.

a. For most of the Department's buildings, a suitable type of computer analysis (dynamic or static) technique or other automated analysis technique (such as the use of programmable calculators), or combinations thereof, shall be used to evaluate energy conservation alternatives. Such computer techniques shall also be used to develop energy-efficient building design concepts and determine the design energy consumption (i.e., estimate of building energy use). The term, "building energy use," means energy use that is principally for heating, ventilation, cooling, domestic hot water, and lighting. Exception to the use of these techniques may be taken for small buildings such as small utility-type buildings, or other buildings with relatively low projected building energy use, where manual analysis methods may be adequate. In general, such exceptions could be taken when building energy use is not expected to exceed 500 million Btu per year (apply conversion values for electricity of 3,412 Btu/kilowatt hour and 1,000 Btu/pound for steam).

b. Analysis techniques in general declining order of sophistication and analysis capabilities, and detail of input data required, are briefly described below:

(1) Dynamic computer analysis techniques, such as DOE 2 (and DOE 2.1) or BLAST, using mainframe CPU (central processing units)/time-sharing computer systems. These techniques provide capability for hour-to-hour load and energy consumption analysis over a full-year study period (see paragraph c, below, for additional information).

(2) Static computer analysis techniques, using mainframe CPU/time-sharing computer systems. These techniques utilize load estimate inputs for peak load periods and generally provide capability for 3-hour interval energy consumption analysis over a full-year study period.

(3) Other static analysis techniques include:

(a) Use of smaller, "minicomputer," systems (present generation not capable of handling the more detailed programs).

(b) Use of simpler, "microcomputer," systems (lower range machine capability than minicomputers, but much faster and more capable than programmable calculators).

(c) Use of programmable calculators in table-top systems including a printer and magnetic card reader, with commercially available programs from calculator manufacturers, or others.

(d) Use of manual analysis methods (generally requiring only a 4-function calculator).

c. It is not within the scope of these criteria to dictate the specific automated analysis technique to be used, as this will need to be determined on a case-by-case basis for each building. However, since dynamic computer analysis techniques, such as DOE-2, currently provide the greatest flexibility and analysis capability, it is recommended that such dynamic techniques be used for the larger, more energy-consuming, buildings. Departmental elements having first-line responsibilities for the design of facilities should assure that capability for use of dynamic techniques, such as DOE 2, is available within their DOE or operating contractor organizations and application of these techniques is made, where feasible. All buildings and building additions of greater than 30,000 gross square feet in size shall be considered for dynamic analysis applications. The magnitude of projected building energy use, type of building occupancy, and opportunities for reducing energy use from non-renewable energy sources on a life cycle cost-effective basis, normally determine if these techniques should be used. There are, generally, four basic program phases in dynamic computer analysis and the related design process in developing energy-efficient building concepts.

(1) Determine the building design heating and cooling loads based upon multiple architectural, mechanical, and electrical systems combinations.

(2) Based on weather data, determine the annual thermal loads for phase (1), above.

(3) Simulate the operation of various mechanical-electrical environmental systems to the thermal load analysis in phase (2), above, to determine hourly, monthly, and annual energy consumption.

(4) Perform life cycle cost analysis for the systems evaluated in phases (1) and (3), above. (See paragraph 4b, above.)

d. Effective application of dynamic analysis techniques, and the more sophisticated static analysis techniques, may often require the type of design detail and other informational input that is developed in the preliminary (Title I) design phase, and sometimes continuing into the detailed (Title II) design phase. Where this is the case, other automated analysis techniques, requiring commensurately less informational input, should be used in the project planning phase for the larger building projects with the objective of identifying the principal energy conservation features. At a minimum, the use of programmable calculator techniques is recommended during the project planning phase for all but the very small building projects, where manual analysis techniques may be adequate. The use of mini- or micro-computer analysis techniques is recommended for other building projects, and these may also be adequate for use during final design for some of the less-complex, less energy-using buildings. However, where the capability exists to use the more sophisticated techniques, such as DOE 2, they should be used wherever feasible. For the larger building projects, where such capability has not yet been developed or is not available from architect-engineer firms in the area, the lesser sophisticated computer analysis techniques should at least be used to assure as energy-efficient designs as practicable.

e. The inside temperatures to be used for building energy consumption analyses shall conform to Federal Property Management Regulations (FPMR), 41 CFR, Chapter 101, Subchapter D, Section 101-20.116 Inside Operating Temperature Requirements, except where the use of other less stringent inside operating temperatures is justified.

6. <u>ENERGY CONSERVATION FEATURES FOR BUILDINGS.</u>

a. <u>Evaluation and Selection of Energy Conservation Features.</u>

(1) Energy conservation shall be given its full share of attention in the planning and design, or acquisition, of DOE buildings. While the basic programmatic or operating requirements must be the principal "driving force" in the development of the building concept and its design, the Federally-mandated requirements to maximize energy conservation on a life cycle cost-effective basis, and with regard to the 45 percent energy-use reduction goal must also be satisfied. Incorporation of energy conservation features on the basis of their life cycle cost-effectiveness will result in some additional

first-costs for building projects. For a typical building project, present indications are that the additional construction costs (first costs) can be on the order of 3-5 percent, or more, depending upon the types and numbers of energy conservation features that are determined to be cost-effective and included in the project. When renewable energy systems, such as active solar systems, are determined to be cost-effective, and included in the project, there will be additional construction costs. From experience, to date, there are indications that these additional construction costs could be on the order of 5-10 percent, or more, for typical building applications.

(2) The additional first-costs for building projects or additional acquisition costs for other buildings such as pre-engineered metal buildings or in-plant fabricated modular buildings, from an energy-use efficiency standpoint, need to be included in the total project cost estimate. Cost allowances also need to be included in the cost estimate for the performance of energy analysis and life-cycle costing evaluations and for contingencies, the same as for other project elements.

(3) Insulating characteristics of the building envelope are of paramount importance with relation to energy conservation for building heating and cooling, and are an integral and dependent element of the architectural and structural building design concept. Therefore, development of basic insulation characteristics shall be considered a prerequisite to follow on evaluation of other energy conservation alternatives on the basis of their life cycle cost-effectiveness. The basic criteria to be applied in architectural and structural planning and design are contained in paragraph b, below and in paragraph 11(1), Chapter IV of this Order.

(4) Evaluation of other energy conservation features (i.e., energy-related building components and systems) shall be based on application of life cycle costing methodologies. Care should be taken to assure that the combination selected will best meet the minimum life cycle cost objective to maximize the net dollar benefits, comparing total energy conservation costs with total energy cost savings. Meeting the objectives is not, usually, only a matter of selecting energy conservation features that are determined individually to be life cycle cost-effective, because of the interdependence that may exist among the different features.

(5) The 45 percent building energy-use reduction goal, as described in paragraph 9 below, shall be applied in planning and designing each building project, in the planning and acquisition of each new pre-engineered metal building and in-plant fabricated modular building, and in the planning and acquisition of other semi-permanent or temporary facilities to the extent that technical specifications can be applied in their acquisition.

(6) See paragraph 9b(3), below, for criteria applicable to analysis of alternate building or building system designs.

b. Building Envelope Thermal Transmittance Values Criteria.

(1) The criteria that follow are to be applied as basic building envelope insulating criteria in architectural and structural planning and design of buildings. They shall also be reflected in specifications that are developed and applied in the acquisition of pre-engineered metal buildings, in-plant fabricated modular relocatable buildings, and other semi-permanent or temporary facilities including trailer units, to the maximum extent feasible. Where pre-constructed facilities, such as pre-constructed trailer units, need to be acquired, only those that meet (or exceed) these criteria should be selected unless suitable improvements are made to meet these criteria, or unless the urgency to satisfy programmatic or operating needs clearly justifies taking exemptions from these criteria.

(2) At a minimum, the thermal transmittance values (U values) as determined from ASHRAE Standard 90A-1980 shall be used as basic building envelope insulating criteria. Wherever possible, the lower U values, comparing those from ASHRAE 90A-1980 with those determined by the procedures below, shall be used. Further adjustment may be needed to achieve the most effective life cycle cost design.

(a) Heating. The annual heating degree-days value for the particular building location, as given in the ASHRAE 'Systems' Volume, shall be used for determining the minimum thermal resistance, or maximum U values. The Q/A values for walls and roofs, as listed in Table 1 and Table 2, below, are to be used without allowance for fenestration or other openings. Where roof slope is achieved by tapered insulation, the average U value of the roof shall be used in load and energy calculations. While ASHRAE 90A-1980 uses an overall $U_o$ value that reflects a more customary allowance for fenestration, in planning and design of new DOE buildings fenestration should be kept to the minimum necessary to satisfy basic functional and operational needs. Maximum allowable heat flow (Btu/hr.ft.$^2$), or heat flux (Q/A), values relate to corresponding degree-day locations as listed in the tables, below. Intermediate degree-day values shall be determined proportionally. The relationships of these factors is shown in the equation below:

$$U = \frac{Q/A}{t_i - t_o}$$

where U = opaque envelope coefficient of heat transmission

Q/A = heat flux, Btu/hr. ft.$^2$
$t_i$ = inside design temperature, $^oF$
$t_o$ = outside design temperature, $^oF$

Table 1

Q/A Values -- Opaque Walls

| Heating Degree-Days | Q/A, Btu/hr. ft.$^2$ |
|---|---|
| 0 | 5.0 |
| 1,000 | 4.5 |
| 2,000 | 4.3 |
| 3,000 | 4.3 |
| 4,000 | 4.3 |
| 5,000 | 4.4 |
| 6,000 | 4.5 |
| 7,000 | 4.8 |
| 8,000 | 5.0 |
| 9,000 | 5.3 |
| 10,000 | 5.6 |
| 12,000 | 5.9 |
| 14,000 or greater | 6.0 |

Table 2

Q/A Values -- Opaque Roof or Ceiling

| Heating Degree-Days | Q/A, Btu/hr. ft.$^2$ |
|---|---|
| 0 | 4.2 |
| 1,000 | 3.7 |
| 2,000 | 3.5 |
| 3,000 | 3.5 |
| 4,000 | 3.5 |
| 5,000 | 3.5 |
| 6,000 | 3.5 |
| 7,000 | 3.6 |
| 8,000 | 3.6 |
| 9,000 | 3.7 |
| 10,000 | 3.8 |
| 12,000 | 4.0 |
| 14,000 or greater | 4.4 |

Table 3

U Values -- Floors (over unheated spaces)

| Heating Degree-Days | Btu/hr. ft.$^2$ $^o$F |
|---|---|
| 0 | No Requirement |
| 500 | 0.23 |
| 1,000 | 0.21 |
| 2,000 | 0.18 |
| 3,000 | 0.16 |
| 4,000 | 0.14 |
| 5,000 | 0.11 |
| 6,000 | 0.09 |
| 7,000 | 0.08 |
| 8,000 or greater | 0.07 |

(b) Cooling. The opaque wall (without allowance for fenestration or other openings) maximum U value shall be determined by the Sol-air Temperature Method as described in the ASHRAE Handbook of Fundamentals. The allowable heat flux, Q/A, shall be 2.0 Btu/hr. ft.$^2$ for determining maximum allowable U factor. No allowance is to be made for fenestration in these computations. The relationships of these factors is shown in the equation below:

$$U = \frac{Q/A}{t_{ea} - t_i}$$

where U = overall coefficient of heat transmission

Q/A = heat flux, Btu/hr. ft.$^2$

$t_{ea}$ = average sol-air temperature, $^oF$ (Attachment XIII-1)

$t_i$ = inside design temperature, $^oF$

(c) Building overall coefficients of heat transmission, or thermal transmittance values, for both heating and cooling modes, shall be computed and the lower values (U values) used. Individual building material thermal resistance (R-values) are listed in the ASHRAE Handbook of Fundamentals, for use in evaluating and selecting from alternative building envelope architectural and structural components.

(d) The water vapor condensation plane within the building envelope shall be determined to assure that condensed vapor can move freely to the atmosphere. The water vapor condensation plane shall be determined for the worst case appropriate to the roof cross-section design. Use of lower U values with related increases in thermal insulation can create potential condensation problems under certain climatic conditions. For guidance, see the section on "Moisture in Building Construction" in the ASHRAE Handbook of Fundamentals.

(e) Deviations from these U value criteria are permitted provided the estimated annual energy consumption from nonrenewable energy sources for heating and cooling does not exceed the allowable consumption as determined in compliance with these criteria. Buildings where renewable energy source applications are being made (e.g., passive solar), or with high internal heat loads (normally in excess of 5 watts per square foot), shall be given special attention to determine the optimum envelope U values.

c. Other Energy Conservation Criteria.

(1) Chapters IV, V, VI, and VIII of this Order contain additional energy conservation-related design criteria to be applied in the planning and design of facilities.

(2) Special attention shall be given to providing energy-efficient central air conditioning units for trailer units or other small buildings or facilities, where cooling is required. The seasonal energy efficiency ratios to be used in specifying equipment below 65,000 Btu/hour in capacity should not be less than 8 Btu/Watt-hour. By definition, "seasonal energy efficiency ratio" (SEER) means the total cooling of a central air conditioner in Btu during its normal annual usage period for cooling, divided by the total electrical energy input in watt-hours during the same period.

(3) Utilization of waste heat and waste heat recovery systems shall be evaluated for building projects, central utilities plants, and for other significant heat-producing process equipment and facility projects. Wherever technically feasible and life cycle cost-effective, heat recovery systems shall be incorporated.

(4) Utilization of cooling energy storage shall be evaluated for building projects, as appropriate. Chilled water storage based on a daily or weekly cycle can significantly reduce initial plant equipment, maintenance, and energy costs (particularly electrical demand charges). Wherever technically feasible and life cycle cost-effective, such energy storage systems should also be evaluated as an emergency supplemental water supply source for fire suppression.

7. ENERGY CONSERVATION FEATURES FOR OTHER PROJECTS. Energy conservation features that are life cycle cost effective shall be included in other facility projects, such as renovations of building, area, and site utility systems and central utilities plants.

8. USE OF RENEWABLE ENERGY SYSTEMS. Subsection (c) of Section 436.51, "Design Program for New Federal Buildings," 10 CFR part 436, "Federal Energy Management and Planning Programs," requires that "Each Federal agency shall plan to install one or more active or passive solar or other renewable energy systems to provide energy for building energy use unless the Federal agency states in its annual report that such a system would not minimize total life cycle costs...." Subsection (a)(3) requires that each Federal agency shall provide, in its Buildings Plan, "For analysis of at least two alternative building designs under Subpart A of this part at least one of which includes a renewable energy system...." Consistent with these regulations, the criteria for the Department's new buildings, building additions, and alterations are as follows:

a. Active Solar Systems. The application of active solar systems shall be evaluated for building projects. These are solar heating and/or cooling systems in which thermal storage devices other than the building mass are used and where thermal energy is transferred in a completely regulated way by pumps or fans. Active solar systems shall be provided wherever they are determined to be technically feasible, life cycle cost effective, and where the total project cost will not exceed applicable statutory limits.

Engineering judgment needs to be exercised in evaluating the potentials for application of active solar systems, and making determinations of when detailed evaluations should be conducted.

(1) Possible active solar system applications include:

(a) Domestic hot water heating.

(b) Process low level water heating.

(c) Space hot water heating.

(d) Solar-assist heat pump.

(e) Space cooling.

(2) A source of information and guidance in the evaluation and design of active solar systems is the "DOE Facilities Solar Design Handbook" of 1-78, DOE/AD-0006/1. Single copies may be obtained by request to the Department's Technical Information Center, P.O. Box 62, Oak Ridge, TN 37830. An additional source of information and guidance is the National Bureau of Standards (NBS) "Guidelines for the Installation of Solar Components on Low-Sloped Roofs," TN 1134, for sale by the Superintendent of Documents, U.S. Government Printing Office (GPO), Washington, D.C. 20402, Stock Number 003-003-02261-6. Also see paragraph 11e, Chapter IV of this Order.

(3) When active solar system applications are not currently cost effective based on life cycle cost analyses for the project, considerations should be given to minimizing future building retrofit costs for later active solar adaptation. Analysis within the past year, for comparable system applications, may be utilized provided they utilize or are modified to utilize current nonrenewable projected costs. Provisions to be considered for possible incorporation in the project include:

(a) Mechanical equipment room space for future solar-related equipment, or ease of room expansion at a later date.

(b) Additional electrical service capacity.

(c) Building structure adequacy (i.e., roof framing) and reserved roof areas to accept solar collectors or reserved ground space for the collectors.

(d) Reserved ground space for locating underground storage tanks.

(e) Compatibility of hot water heating system for future use of low temperature solar-heated water. See paragraph 6c, Chapter V, of this Order for additional criteria.

b. <u>Passive Solar Systems.</u> The application of passive solar systems shall also be evaluated for building projects. Passive solar systems shall be provided wherever they are determined to be technically feasible and life cycle cost effective, and where the total project cost will not exceed applicable statutory limits. Engineering judgment needs to be exercised in evaluating the potentials for applications of passive solar systems and making determinations of when detailed evaluations should be conducted.

(1) Fundamentally, passive solar systems are those characterized by reliance on natural thermal energy flow (radiation, conduction, convection), and by energy collection and storage media that are intrinsic parts of the building. Efficient operation of passive systems involves control of thermal energy flow, including the ability to control energy flow entering or escaping from the building (built-in sunshading such as building overhangs, shutters and movable insulation panels for glazed collector areas, and so forth) and the flow within the building (opening and closing of spaces).

(a) A <u>Direct Gain</u> passive system may be defined as one where the solar radiation passes through collector glazing (windows or skylights) and building space, before being absorbed and stored in a thermal mass.

(b) An <u>Indirect Gain</u> passive system may be defined as one where the solar radiation is first absorbed and stored in a thermal mass from which thermal energy is then transferred into the building space. Specifically, the storage media intercedes between the sun and the building space. Examples are mass trombe or water trombe wall storage systems where solar radiation is intercepted directly behind glazed areas by massive walls, or water containment for heat storage.

(c) An <u>Isolated Gain</u> passive system may be defined as one where solar radiation is collected and stored in a space separate from functional building spaces, but directly linked thermally. Typically, it is an atrium, sunporch, sunroom, or greenhouse concept with thermal mass storage and energy transfer capability.

(2) For greater operating efficiency, mechanical means can be employed to assist energy flow, either from the collector area to storage or from storage to building spaces, with the use of fans, plenums, and ducting systems. This mechanical system can be either separate or integral to the standard building mechanical system. This is termed a hybrid solar system--neither purely passive nor active.

(3) Environmental interaction with the building is basic to passive solar operation and influences building siting, shape, orientation, internal space arrangements, fenestration, and other construction

features. Passive solar applications are also interrelated with or interdependent on such design parameters and requirements as building size, climatic conditions, building functions, levels of internally-generated thermal loads (mechanical-electrical systems, equipment, occupancy, and so forth) and space environmental requirements for occupants and functions.

(4) A source of guidance in the evaluation and design for passive solar applications is the two-volume DOE "Passive Solar Design Handbook": Volume One, "Passive Solar Design Concepts" of 3-80, DOE/CS-0127/1 and Volume Two, "Passive Solar Design Analysis" of 1-80, DOE/CS-0127/2. Single copies, or a set, may be obtained by request to the Department's Technical Information Center, P.O. Box 62, Oak Ridge, TN 37830.

c. Other Renewable Systems. The opportunity for application of other renewable energy sources in facility projects (photovoltaics or other renewable energy applications) should be evaluated on a case-by-case basis. Evaluations and selections should be based on the application of life cycle costing methodologies.

9. ENERGY-USE REDUCTION GOALS FOR NEW DOE BUILDINGS.

a. Application of the 45 Percent Reduction Goal.

(1) Executive Order (E.O.) 12003 and Federal Regulations, 10 CFR part 436 established two energy use reduction goals for owned and leased new Federal buildings. Both goal's "average energy use" is computed on the basis of annual use per gross square foot of floor area.

(a) The individual new building design goal of a 45 percent reduction in average building energy use over the average energy use of a representative Federal building of the same category completed prior to FY 1975.

(b) The overall Department "end goal" of 45 percent reduction in average energy use for all new buildings in FY 1985 over the average energy use for all buildings of the Department in FY 1975.

(2) For application purposes, a building shall be considered new if either of the following apply:

(a) Construction was not complete prior to November 9, 1978, and design could be feasibly modified after November 14, 1979; or

(b) Design started after November 9, 1979.

(3) For application purposes, a leased building is included if construction had not started prior to July 20, 1977.

In determining if the design can be feasibly modified, such factors as schedule effects and cost limitations shall be considered.

(4) It is important to keep in mind that the Department's "end goal" is a 45 percent reduction in average energy use per gross square foot for the total of all its new buildings in Fy 1985, from the average energy use per gross square foot of existing buildings in FY 1975. To achieve the "end goal" the average energy use reduction of all new buildings must be equal to 45 percent. This can only be met if all new buildings equal or exceed the individual building goal, or new buildings exceeding the 45 percent goal offset those that do not meet the individual buildings goal.

(5) All new DOE buildings will not have the same opportunities for reducing building energy use. It may not be possible for some buildings to achieve the 45 percent reduction goal, such as warehouse/storage facilities with minimal heating and lighting requirements and no cooling requirements. If DOE is to fully achieve the reduction goal for all of its new buildings, special attention needs to be given to meeting the goal for the energy-using buildings having large potentials for energy-use reduction, and to exceed the goal for these facilities, wherever feasible.

(6) Subsection (a)(3) of section 436.51, 10 CFR part 436, requires each Federal agency to provide in its Buildings Plan "For analysis of at least two alternative building designs using Life Cycle Cost Analysis, at least one of which includes a renewable energy system. Both alternative designs must be consistent with budget limitations and basic requirements for heating, ventilation, cooling, lighting, domestic hot water, and functional purposes."

(a) This requirement shall not be construed as requiring two completely different overall building design concepts for all new DOE buildings. The Final Rule on this subject, as published in the Federal Register of 11-14-79, contains the following clarifying information and guidance.

> "The purpose of requiring analysis of more than one design is to promote a minimum level of exploration of design alternatives. Section 436.51 should be interpreted broadly. There should at least be a comparison to two or more component designs within a common approach. For more complex designs, DOE encourages, but will not mandate, a comparison of two completely different overall designs which could also have component design variances. Each agency should analyze reasonable alternatives since each agency has the ultimate responsibility in achieving the most 'cost-effective' design consistent with the energy reduction goal of 45 percent."

(b) Therefore, in applying this requirement the fundamental objective will be to evaluate alternative building systems and other energy-related features (components) and make selections from the standpoint of life cycle cost-effectiveness. The term, "building system," as defined in 10 CFR part 436, "means any part of the structure of a Federal building significantly affecting building energy use, or any energy using system contributing to building energy use."

1 Where a single overall building design concept, will not be expected to achieve the 45 percent reduction goal, an alternate concept may need to be evaluated. However, engineering judgment is needed here. For example, small buildings, or other buildings with low projected energy consumption and having limited opportunity for significant improvement in energy-use, the additional cost for making alternate design studies may often exceed the benefits to be achieved. For larger energy-using buildings or building additions having greater opportunities for significant improvements in energy efficiency, evaluation of alternate overall building design concepts may need to be made.

2 For the larger or more complex building projects, alternate overall building design concepts may often be evaluated for reasons other than for energy conservation specifically, such as to develop the best concept for satisfying programmatic or operating needs, which is the fundamental requirement in the planning and design or acquisition, of any building. In the evaluation of such alternate concepts, energy conservation shall be given its share of attention. Where energy conservation can be the discriminating factor between programmatic or operating needs options, it shall be applied in the option selection.

b. Estimating Energy Use of a Representative Building in FY 1975. For application of the 45 percent reduction goal to a new building, a reasonably accurate estimate of the building energy use for a representative building of the same category (and in the same general climatic region) in FY 1975, is needed. In many cases, accurate data will not be available, and a "best-judgment" approach will need to be taken. However, where computer or other automated analysis techniques are being used for energy analysis of the new building, during planning or design, a "simulation" of energy use for this building, as if it had been constructed in early-to-mid 1970's, may be a feasible method. This and other possible approaches are described below:

(1) By means of an energy audit of an existing building of that category on the particular site, or in the general area, that was completed in the FY 1970 - FY 1975 time period.

(2) From metered energy use of such existing buildings, either onsite or in the general area, when available.

(3) By a simulated energy-use analysis of the new building that is under planning or design, by applying the design and construction standards and criteria that were in use, by the Department or architect-engineer firms in the general locality during the FY 1970 - FY 1975 time period. (The then-applicable building envelope insulation standards; building design temperature criteria; interior illumination levels; building fenestration criteria; types of heating, ventilating, and air conditioning systems used; building operation features, such as HVAC controls, lighting controls). In making comparisons of the estimated building energy use of a new building with respect to the 45 percent reduction goal, exclude any estimate of energy to be supplied from a renewable energy source.

10. ESTIMATES OF ADDITIONAL CONSTRUCTION COSTS FOR NEW DOE BUILDINGS.

a. Federal Regulations in 10 CFR part 436, require that estimates be made and documented of the additional construction cost attributable to incorporation of energy conservation systems into new building designs, in order to achieve the 45 percent goal. The regulations in 10 CFR part 436 further require estimates of the related energy cost savings over the projected useful facility life. The term 'alternative building system' means a primarily energy-saving building system, including a renewable energy system, for consideration as part of the design for a new Federal building.

b. The above regulation provisions can be met by properly structuring the life cycle cost analysis required and described in this chapter.

c. Estimates of additional construction costs and energy cost savings for new DOE buildings are to be included in the Energy Conservation Report for the project. See paragraph 14, below.

11. BUILDING ENERGY PERFORMANCE STANDARDS.

a. The Department of Energy has responsibilities for the development and promulgation of "energy performance standards" for new commercial and residential buildings. Proposed Rulemaking (subpart A of 10 CFR part 435) was published in the Federal Register of 11-28-79. Section 306 of the "Energy Conservation Standards for New Buildings Act of 1976," requires that Federal agencies assure that new Federal buildings meet or exceed the applicable performance standards when they are promulgated for use. This requirement is also stated in section 436.52(b), subpart C of 10 CFR part 436.

b. When promulgated, applicable building performance standards for Federal buildings shall not be construed as limiting further reduction in energy use of the Department's new buildings where such further reduction can be achieved on the basis of life cycle cost analysis. The "energy performance standards" do not relate to the 45 percent building energy reduction goal for new Federal buildings. When the energy performance standards are promulgated for use, the lesser energy-use value, between the applicable energy performance standard and the energy use value necessary to achieve the 45 percent reduction goal, shall be applied in the planning and design, or acquisition, of new DOE buildings.

12. ENERGY MANAGEMENT SYSTEMS AND DEVICES.

a. Energy management systems and devices are characterized by their ability to control energy consuming systems or equipment. Examples of simple devices are manual valves and electrical switches. An example of a simple automatic energy management device is a single set-point thermostat. Moving to higher levels of complexity, technology, and methodology, a typical example would be a computer-based energy monitoring and control system (EMCS).

b. The application of energy management systems and devices will often directly interface with the architectural, mechanical and electrical design requirements for a building. They also interface with telecommunications system design requirements where telecommunication circuits are used both within the building and from building-to-building on the site. Close coordination needs to be maintained among all affected design disciplines, during the planning and design of energy management systems.

c. Energy monitoring and control systems (EMCS) usually consist of a central computing system with peripheral equipment, data transmission media, field interface devices, multiplex panels, necessary interfacing controls, and sensors. Each field interface device will generally contain a microcomputer that performs certain local control functions in a stand-alone mode of operation.

(1) Criteria and methodology for the design of an EMCS should be obtained from U.S. Army Corps of Engineers Technical Manual, TM 5-815-2, "Energy Monitoring and Control Systems."

(2) Guidance for preparation of design and procurement documents should be obtained from the following U.S. Army Corps of Engineers Guide Specifications.

(a) CEGS-13947, "Large Energy Monitoring and Control Systems."

(b) CEGS-13948, "Medium Energy Monitoring and Control Systems."

(c) CEGS-13949, "Small Energy Monitoring and Control Systems."

(d) CEGS-13950, "Micro Energy Monitoring and Control Systems."

(3) A methodology for estimating the economics and energy conservation performance of an EMCS may be obtained by adapting the guidance in Navy Civil Engineering Laboratory document, "EMCS Economic Analysis Guideline," PO No. 78 MR 423, to be consistent with the "Life Cycle Cost Analysis," of this Chapter XIII.

13. ENERGY METERING.

a. The intent of these metering criteria is to:

(1) assure that all significant utilization of energy in all of the Department's new owned and leased buildings and facilities is metered in accordance with 10 CFR part 436;

(2) provide submetering for process and production energy usage within the Department's new buildings and facilities;

(3) provide a means for validation of the Department's progress toward goals for effective energy efficient design in new buildings (see paragraph 2c(2));

(4) assure that the Department's new buildings and facilities are provided with sufficient metering to facilitate compliance with the energy usage reporting requirements of 10 CFR 436 and DOE 4330.2A.

(5) measure the effectiveness of corrective and energy conserving actions taken during the operation of a building; and

(6) identify capabilities for emergency energy use reduction during periods of shortages and curtailments.

b. Permanent metering shall be provided for each type of energy supplied to and consumed by the Department's owned and leased new buildings and facilities with the following exemptions:

(1) Permanent metering of the energy supplies to small buildings and facilities, and other buildings and facilities having relatively low total energy usage is not required. This exemption may generally be appropriate for a new temporary office facility, new perimeter guard station buildings, small storage and utility buildings, and other facilities where the individual total energy usage is not expected to exceed 500 million Btu per year. (Apply conversion values of 3,412 Btu/kilowatt hour for electricity and 1,000 Btu/pound for steam.)

(2) Normally, permanent metering is not required for a type of energy supply that is estimated to supply 10 percent, or less, of the total energy input to the building.

(3) Metering of energy supplied from a renewable energy source or from waste heat and waste heat recovery generally will not be required. However, where energy metering is feasible and if the information

gained is to be used to evaluate the effectiveness of the renewable energy systems or controls, permanent metering or features for ease of temporary metering should be provided.

c. Permanent submetering shall be provided for each type of process and production energy consumed in the Department's owned and leased new buildings and facilities except where the cost of providing the submetering becomes excessive compared to the management benefits gained. When permanent submetering is not provided, a discussion of the rationale for the exclusion shall be included in the Energy Conservation Report documentation. (See paragraph 14a(4).)

(1) Process energy means energy for production and research processes and does not include building energy. Building energy means energy used principally for heating, ventilating, cooling, domestic hot water and lighting.

(2) Generally, where the total process use is only about 10 percent or less of the total energy input to the building that total energy input may be considered as "building energy use." Conversely, where the total process energy use is about 90 percent or more of the total energy input to the building that total energy input may be considered as "process energy use."

d. In order to comply with the provisions of 10 CFR part 436 and DOE 4330.2A, the Department reports energy consumption in its buildings and facilities, establishes consumption goals, and develops 10-year Plans for "buildings energy" and "metered process energy" consumption. The metering features incorporated into the design will predetermine the manner in which energy consumption will be reported for new buildings or facilities as follows:

(1) If a facility has submetering to separate building energy and process energy usage within the facility, then;

(a) the building energy and the process energy will be separately reported as "building energy" consumption and "metered process energy" consumption in the Energy Conservation Report documentation and the Quarterly Energy Conservation Performance Report required by DOE 4330.2A.

(b) the development of the estimated total annual energy consumption that will be included in the Energy Conservation Report documentation (see paragraph 14) must be separated into building energy and metered process energy corresponding to the meters and submeters incorporated in the facility. The separation by energy use category is necessary for the reporting and subsequent validation of the Department's progress toward goals for energy efficient design in new buildings.

(2) If a building or facility is not provided with submetering for process or production energy usage, then:

(a) those buildings or facilities with predominant building energy usage will have the entire energy usage reported as building energy in the Energy Conservation Report documentation and the Quarterly Energy Conservation Performance Report (QECPR) required by DOE 4330.2A;

(b) those buildings or facilities with predominant process energy usage will have the entire energy usage reported as metered process energy in the Energy Conservation Report and the QECPR; and

(c) The decision not to provide submetering and the subsequent determination to report the entire energy usage of a building or facility as all building or all metered processes energy must be made by the appropriate DOE Energy Coordinator and an explanation of the decision and determination must be included in the Energy Conservation Report documentation.

e. Energy metering requirements need to be established prior to establishing the official project cost estimate for authorization to assure that the capital costs are properly included in the total project cost estimate.

f. In the selection of metering devices, proper consideration shall be given to compatibility for use with an existing or projected energy monitoring and control system (EMCS).

14. DOCUMENTATION.

a. Energy Conservation Report. An energy conservation report (summary evaluation) shall be developed for each new building, building addition, appropriate building alteration, and other energy-using projects. The initial report, covering such data and information as can be developed during the project planning phase, shall be included as a part of the appropriate project planning documents (conceptual design reports or other project planning documents). These initial analyses shall be updated at the end of preliminary (Title I) design and included as a part of the appropriate design documents (updated conceptual design reports, Title I design reports, or other Title I design documentation). They shall be further updated as a part of Title II design documentation, when final selections of energy conservation features or renewable energy sources are not made until the Title II design phase.

(1) Analyses for building or building addition projects shall include:

(a) Identification of methods used for building energy consumption analyses. This analysis includes loads and building systems analysis (computer dynamic analysis, other computer analysis, use of programmable calculator, or manual calculations).

(b) Methodology of life cycle costing analysis for the evaluation and comparison of energy conservation alternatives and use of renewable energy sources (computer dynamic analysis, other computer analysis, use of programmable calculator, or manual calculations).

(c) Description of the major energy conservation features selected, such as building envelope U values (or R values), type of fenestration and percent of gross wall area, type of air handling system, reheat systems, automatic system control features, central supervisory and control features, lighting levels and controls, and so forth.

(d) Results, including backup data (or identify source for obtaining data on an as-requested basis) of life cycle cost analyses of active or passive solar system applications or other renewable energy source applications, as appropriate.

(e) Discussion of evaluations made of nonrenewable energy supply alternatives, and basis for selection(s). Discussion shall include determination of conformance with the Department's fuels and energy use policy (DOE 4330.3).

(f) Estimates of total energy input to the building (see paragraph (3) below, for energy conversion values). Estimates shall be subdivided as follows:

1 For buildings incorporating submetering, separately identify building energy and metered process energy and the number of square feet associated with each type of energy usage. Include:

a Btu/year by types of energy.

b Total Btu/year.

c Btu/gross square foot/year.

2 For buildings without submetering, identify the energy usage type as either entirely building energy or entirely metered process energy and the number of square feet associated with the type of energy usage. Identification of energy usage types (building or metered process) and associated number of square feet must correspond to the actual metering and submetering features incorporated. Include:

a Btu/year by types of energy.

b Total Btu/year.

c Btu/gross square foot/year.

(g) Provide the following information with regard to the 45 percent energy-use reduction goal (see paragraphs 9 and 10, above):

1 Estimated baseline building energy use of a representative building of the appropriate category in FY 1975. Provide information corresponding to paragraph 14a(1)(f), above.

2 Estimated percentage of energy-use reduction (if less than the 45 percent goal, provide brief explanation).

3 Method used to estimate the baseline energy use of a representative building of the appropriate category in FY 1975 (see paragraph 9b, above).

4 Estimated additional construction costs to achieve the 45 percent goal, or to achieve the estimated percent reduction if either higher or lower than this goal (do not adjust these estimated costs to a 45 percent energy use reduction level).

5 Estimated energy cost savings over the projected life of the building (with respect to the additional investment costs in 4, above). Include the first year energy unit cost, the first year energy cost savings, and the present worth factor for each energy source included in the computation. The projected life of the building used in the computation shall also be included.

(h) Provide a comparison of estimated building energy use with applicable building energy performance standard for Federal buildings (see paragraph 11, above). This information is not required until such time as these standards are promulgated for required use.

(2) Reports for other energy-using facility projects (other than buildings/additions) shall include:

(a) Discussion of life cycle cost analyses made of energy conservation features and selections made, analyses of renewable energy source applications, evaluations made of nonrenewable energy supply alternatives and basis for selection(s), and conformance with the Department's fuels and energy use policy (DOE 4330.3).

(b) Estimates of energy use, and energy savings achieved, in Btu per year, by types of energy and total. See paragraph (3), below, for energy conversion values.

(3) Energy conversion values, from 10 CFR part 436, are listed below:

| | |
|---|---|
| Electricity | 11,600 and 3,412 Btu/kilowatt hour |
| Fuel Oil (distillate) | 5,825,400 Btu/barrel |
| Residual Fuel | 6,287,000 Btu/barrel |
| Natural Gas | 1,030,000 Btu/1000 cubic feet |
| Liquified Petroleum Gas (LPG) including propane and butane | 4,011,000 Btu/barrel |
| Coal | 24,500,000 Btu/short ton |
| Steam (purchased) | 1,390 and 1,000 Btu/pound |
| Energy sources not listed | Conversion factors from a standard engineering reference manual or other reliable reference. |

The higher values for electricity and steam are only to be used in reporting energy use and energy savings. As stated in 10 CFR part 436, subpart 436.45, "---in calculating energy costs for life cycle costing purposes, only the conversion values of 3,412 Btu per kilowatt hour of electricity and 1000 Btu per pound of steam (purchased steam) shall be used."

(4) Energy metering provisions shall be discussed in the energy conservation report including types of permanent metering for energy inputs to the building, types of submetering for process energy use, compatibility with existing or projected energy monitoring and control systems (EMCS), and an estimate of the total costs for metering and submetering provisions. Include a narrative of the actions taken and the decisions and determinations made to assure compliance with the energy metering criteria in paragraphs 13c and 13d(2)(c). If metering provisions are not being made, provide brief explanation.

b. Distribution of Project Planning and Design Documents. In addition to other recipients of project planning and design documents (conceptual design reports, Title I design reports, Title II updates of information previously reported or not previously available, or other design documentation), DOE field organizations are requested to provide one copy of each document to the In-House Energy Management Branch, Office of Project and Facilities Management, at DOE Headquarters. The energy conservation reports and other directly-related information in these documents, is needed by the In-House Energy Management Branch for fulfillment of its energy management program responsibilities, including the reporting requirements under the provisions of 10 CFR part 436, "Federal Energy Management and Planning Programs."

# DETERMINATION OF THE AVERAGE SOL-AIR TEMPERATURE

$$t_{ea} = t_{oa} + \frac{\alpha}{h_o}\frac{(I_{DT})}{24} - \frac{\epsilon \Delta R}{h_o}$$

for walls: $$t_{ea} = t_{oa} + \frac{\alpha}{h_o}\frac{(I_{DT})}{24}$$

where $t_{ea}$ = average sol-air temperature, °F

$t_{oa}$ = average summer design outdoor temperature, °F

$$t_{oa} = t_d - \frac{\Delta t}{2}$$

$t_d$ = outside air design temperature, °F

$\Delta t$ = outside air daily range, °F

$\frac{\alpha}{h_o}$ = 0.15 for light-colored surfaces; 0.30 for dark-colored surfaces

$I_{DT}$ = 1.15 times maximum sum of the two half-day totals of solar heat gain factors for each wall as given in the Tables in Chapter 27, 1981 ASHRAE Handbook of Fundamentals, Btu/hr. ft.$^2$

For additional information and examples, refer to the National Bureau of Standards document NBSIR-74-452, Design and Evaluation Criteria for Energy Conservation in New Buildings, dated February 27, 1974. Copies are available from the Division of Real Property and Facilities Management.

# CHAPTER XIV

(RESERVED)

(SAFEGUARDS AND SECURITY - PHYSICAL PROTECTION)

To be issued

# CHAPTER XV

(RESERVED)

(STEAM GENERATION AND DISTRIBUTION)

To be issued

# CHAPTER XVI

(RESERVED)

(OFFICES AND ADMINISTRATIVE FACILITIES)

To be issued

## CHAPTER XVII

## LABORATORIES AND LABORATORY BUILDINGS

1. COVERAGE. These criteria, supplementing the basic design criteria in Chapters I through XV of this Order, shall be applied in the planning and design of laboratory facilities. Because of the wide variety of DOE laboratory requirements, there will be some types of laboratory facilities that have not been adequately covered, such as laboratories for carcinogens and pathogens. Additional criteria will need to be applied to satisfy the particular health, safety, and environmental protection requirements or other special requirements, on a case-by-case basis.

2. CODES, STANDARDS, GUIDES, AND DOE DIRECTIVES. In addition to the basic building codes identified in paragraph 3, Chapter I, and other applicable codes, standards, guides, and DOE directives identified in Chapters I through XV of this Order, the latest editions of those listed below shall also be followed.

   a. National Fire Protection Association (NFPA) Codes and Standards:

      (1) NFPA 45, "Fire Protection for Laboratories Using Chemicals."

      (2) NFPA 49, "Hazardous Chemicals Data."

      (3) NFPA 50, "Standard for Bulk Oxygen Systems at Consumer Sites."

      (4) NFPA 50A, "Standard for Gaseous Hydrogen Systems at Consumer Sites."

      (5) NFPA 50B, "Standard for Liquified Hydrogen Systems at Consumer Sites."

      (6) NFPA 54 (ANSI Z223.1), "National Fuel Gas Code."

      (7) NFPA 56C, "Standard for Laboratories in Health Related Institutions."

      (8) NFPA 58, "Standard for the Storage and Handling of Liquified Petroleum Gases."

      (9) NFPA 68, "Guide for Explosion Venting."

      (10) NFPA 70 (ANSI/NFPA 70), "National Electrical Code."

      (11) NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."

      (12) NFPA 91, "Standard for the Installation of Blower and Exhaust Systems for Dust, Stock, and Vapor Removal or Conveying."

(13) NFPA 101, "Life Safety Code."

(14) NFPA 325M, "Fire Hazard Properties of Flammable Liquids, Gases, and Volatile Solids."

(15) NFPA 491M, "Manual of Hazardous Chemical Reactions."

(16) NFPA 493, "Standard for Intrinsically Safe Apparatus for Use in Class I, II, and III, Division 1 Hazardous Locations."

b. American National Standards Institute (ANSI) Standards:

(1) ANSI A13.1, "Scheme for the Identification of Piping Systems."

(2) ANSI/UL 779, "Safety Standard for Electrically Conductive Floorings."

(3) Other standards for laboratories involving use of nuclear materials:

(a) ANSI N13.1, "Guide to Sampling Airborne Radioactive Materials in Nuclear Facilities."

(b) ANSI N13.3, "Dosimetry for Criticality Accidents."

(c) ANSI/ANS 8.3, "Criticality Accident Alarm Systems."

(d) ANSI N101.6, "Concrete Radiation Shields."

(e) ANSI N512, "Protective Coatings (Paints) for the Nuclear Industry."

(f) ANSI/ASME N510, "Testing of Nuclear Air Cleaning Systems."

(g) ANSI N42.18, "Specification and Performance of On-Site Instrumentation for Continuously Monitoring Radioactivity in Effluents."

c. Factory Mutual Loss Prevention Data Sheet 7-50, "Compressed Gas in Cylinders."

d. American Society of Heating and Air Conditioning Engineers (ASHRAE):

(1) Applications Handbook, "Laboratories" chapter.

(2) Fundamentals Handbook, "Air Flow Around Buildings" chapter.

e. American Industrial Hygiene Association (AIHA), "Industrial Hygiene Practices Guide: Laboratory Hood Ventilation."

f. American Conference of Governmental Industrial Hygienists (ACGIH), "Industrial Ventilation: A Manual of Recommended Practice."

g. Oak Ridge National Laboratory Technical Manual, ORNL/TM 6400, "Minimum Acceptable Face Velocities of Laboratory Fume Hoods and Guidelines for Their Classification."

h. "Electrical Safety Criteria for Research and Development Activities," DOE/EV-0051/1.

i. U.S. Department of Labor, "Occupational Safety and Health Standards," 10 CFR Part 1910.

j. DOE 3790.1, OCCUPATIONAL SAFETY AND HEALTH PROGRAM FOR FEDERAL EMPLOYEES, of 12-11-80.

k. DOE 5480.1A, ENVIRONMENTAL PROTECTION, SAFETY, AND HEALTH PROTECTION PROGRAM FOR DOE OPERATIONS, of 8-13-81.

3. <u>PLANNING AND DESIGN FUNDAMENTALS</u>.

a. <u>General</u>.

(1) Health, safety, and environmental protection requirements shall be given close attention in the planning and design phases. Most laboratories, by the nature of the chemical, biological, electrical, radiation and other hazards that exist, will require that comprehensive safety analyses be made of the hazards. Input, advice and guidance shall be obtained from the cognizant DOE and DOE operating contractor personnel, and from consultants in specialty areas when necessary.

(2) Whenever feasible, laboratory facilities shall be planned and layout developed on the basis of repetitive modules with laboratories back-to-back and side-by-side in multi-laboratory buildings, grouped according to laboratory services, heating, ventilating, and air conditioning (HVAC) requirements, functional disciplines, and operating hazards. Unless there are specific requirements for providing office areas within the laboratories, they should be located with other offices and common-use facilities (e.g., data computation and processing, balance rooms, word processing), in a centralized location. Arrangement of laboratory furniture, hoods, sinks, piped services, lighting, electrical receptacles, and other laboratory features should also be repetitive for laboratories having similar use requirements, with space for special and movable equipment restricted to specific locations.

(3) Facility layout, estimated space requirements for the functions to be performed and equipment to be installed, and personnel traffic flow patterns shall be developed during the planning phase, and further refined during preliminary (Title I) design as necessary, with particular emphasis placed on efficient layout and safety of personnel. Wasted space through inefficient laboratory and office space layout and support facilities' layout, corridor layout,

unnecessary lobbies, and monumental spaces shall be avoided. Safe access, egress, and internal traffic flow are important objectives.

(4) Energy conservation shall be given particular attention in the planning and design of laboratory facilities, as further covered in these criteria. This includes both energy conservation in building energy use to satisfy the goals and requirements contained in Chapter XIII of this Order, and in energy use for laboratory operations (process energy use). The heating, ventilating and air conditioning (HVAC) loadings for most laboratories containing fume hoods and other special ventilation requirements are generally of sufficient magnitude to require particular attention to the potentials for energy conservation. Significant energy savings for heating and cooling may be realized, based on life-cycle cost effectiveness of energy conservation features. However, any such features should only be incorporated where they do not compromise the safety and health of personnel.

(5) When planning new laboratory facilities or major alterations or additions to existing facilities, recognition needs to be given to the commonality in laboratory requirements among the various DOE sites. Where similar types of facilities exist, or are being planned, maximum use should be made of the design and construction approaches taken, construction and operating economies achieved, and "lessons learned." Efforts should be made, during the planning phase, to obtain information from other DOE sites recent laboratory construction experiences to take advantage of new or innovative techniques and to avoid repeating less than successful experiences.

b. Flow Diagrams. Flow diagrams shall be developed tracing HVAC air flows, compressed air and other principal gas or liquid flows, and process (including material) flow to assure satisfaction of health, safety, and environmental protection needs. Differential air pressures, volumes, rates of air changes per hour, temperature and relative humidity requirements, degrees of cleanliness and filtration required, and other operating requirements shall also be identified.

c. Building Services and Distribution.

(1) Laboratory services and building utilities shall be planned to achieve maximum flexibility and ease of access. Vertical and horizontal headers should be specifically located as planning and preliminary design progresses.

(a) Zones (space) in vertical and horizontal service chases shall be established, service header sizes determined and spaces assigned, with priority given to gravity-flow piped services and utilities and large air distribution and exhaust duct headers. Vertical chases shall be provided with fire cutoffs, preferably at each floor level and at the enclosing partitions, consistent with the building construction code classification. Suitable access doors or removable panels shall be provided in service chases for access to valves, air dampers, and so forth. Equipment selections shall be made from products listed by Underwriters Laboratories (UL) or other approved testing organization, as necessary, to maintain the degree of protection required by the particular building code classification.

(b) Access to hazardous gas storage areas and to electrical power and distribution panels shall be controlled by locked gates, doors, power panels, or other physical barriers for personnel safety and effective administration and control of laboratory operations.

(2) Where continuous laboratory services are required, service headers shall be looped and appropriately valved to maintain such services during routine maintenance or system alterations.

(3) Laboratory services shall extend from horizontal service headers Services should be located to avoid penetration of adjacent laboratory walls and floors, where routine maintenance or alterations of these services would result in undesirable curtailment or interruption of operations in the adjacent laboratories.

d. Utilization Schedule. A laboratory utilization schedule shall be developed to show the intended schedule of operations of energy-using systems and equipment. These schedules need to be utilized in performing computerized or other energy-use analyses in developing energy-efficient facility design. Particular care needs to be taken to identify the use requirements of such large energy consumers as exhaust hoods and other high volume air-using equipment to assure that such equipment is properly designed, and that operating control features are provided such that the equipment can be easily "shut down" during periods of non-use wherever personnel health and safety will not be adversely affected.

4. ARCHITECTURAL AND STRUCTURAL.

a. General.

(1) The physical arrangement, size, structural system, materials of construction, and finishes shall be such as to result in a pleasant, efficient, safe, and functional environment for the activities and operations to be performed.

(2) Flammable liguids and gases, explosive mixtures, hazardous or toxic chemicals, biological agents, and pyrophoric or radioactive materials present significant fire, explosion, and other safety hazards for most laboratory facilities. This will require careful safety analyses and special design attention, including consultation with

cognizant DOE and DOE operating contractor personnel, or with other specialists in the appropriate subject areas.

(3) The type and level of hazard shall be determined for each functional area of the laboratory facility, the attendant degree of risk established, and the possibility of cross-contamination analyzed. Areas for work with radioactive or other hazardous contaminants shall be grouped together wherever possible, to simplify solutions to problems of air supply and exhaust, waste disposal, decontamination, and cross-contamination.

b. Building Layout.

(1) The building layout plan shall group areas of like physical characteristics and requirements. A minimum number of entrances shall be provided for security areas. However, exits shall be adequate to satisfy the requirements of the National Fire Protection Association (NFPA) Life Safety Code. Some exits may be provided for emergency use only, and equipped with alarm devices and seals. At least two exits shall be provided in rooms where hazardous materials are handled. NFPA Standard No. 45, "Standard for Fire Protection of Laboratories Using Chemicals," shall be followed.

(2) Laboratory modules shall be developed to provide maximum functional utilization of space. Suggested dimensions for modules or standard laboratory units, adaptable to a variety of laboratory requirements, are: 10 or 20 feet wide by 20 feet long; 10 or 20 feet wide by 24 feet long; or, 12 or 24 feet wide by 24 feet long. Experience has demonstrated that a working aisle width between lab benches of between 4-1/2 feet and 6 feet is adequate for laboratory rooms utilizing standard lab bench and hood units. Where laboratory operations require the use of extensive floor-mounted equipment bench units should be supplanted by the equipment and the working aisle dimensions determined based upon equipment operating and maintenance needs. In all cases, aisle space requirements shall be carefully evaluated with respect to laboratory operation needs. It should be recognized that aisle space allowances can be a controlling factor in building layout and in building size. With maximum bench and equipment space as a primary objective for best utilization of space, unnecessarily wide aisle allowances can then dictate the selection of unnecessarily large modules. If the number of laboratory modules is the governing criteria for the project, an increase in building size (and cost) can often result, or alternatively, a decrease in space allowances for other functions within the building. For general guidance, Attachment XVII-1 contains some typical laboratory module layouts that illustrate efficiency in layout, common use of pipe and utility chases, and other features.

(3) Auxiliary space allotments within laboratory buildings shall be held to a minimum consistent with operational efficiency. For office space that is to be provided in laboratory buildings, space allowances for planning purposes shall be in accordance with paragraph 4f in Chapter IV. The location of storage areas (or vaults) shall be carefully planned, giving consideration to hazards of materials stored (e.g., radiation and criticality of nuclear materials), fire-fighting capabilities, contamination control, and so forth. Storage areas having heavy floor loadings should preferably be placed on grade, or compacted fill.

(4) Story height shall be held to a minimum consistent with the structural framing system, required laboratory equipment height, and building utility systems. Generally, a clear-height of 9 feet will be adequate with floor-to-floor height not exceeding 12 feet, except where specific functions require special hoods or special ventilation systems or where high-bay space is required for engineering development, semiworks, other equipment, or similar functional use. Suspended ceilings may be utilized where economical, a reduction in HVAC loads and energy costs will result, they are necessary to provide required acoustical properties, will minimize the spread of contaminants, or facilitate the maintenance of acceptable levels of cleanliness. Where the use of suspended ceilings is justified, floor-to-floor heights and space above the suspended ceilings shall be held to the minimum required to accommodate concealed piping, ducts, structural framing, and so forth.

(5) Where an acceptable working environment can be provided by careful layout of exposed framing, piping, and ducts, the roof or overhead floor construction shall be designed to obviate the need for ceiling finish (other than painting) or applied or integral acoustical treatment.

(6) Attention shall be given to corridor sizing in building layout planning. Corridor width(s) can be a controlling factor in the overall building size, and unnecessarily wide corridors may contribute to higher building costs with no significant benefit. All corridors and door openings shall meet NFPA "Life Safety Code" requirements or more stringent requirements, based on the hazards of materials to be handled or operations to be performed, as established by the responsible DOE health and safety authority having jurisdiction. In sizing and arranging interior corridors, personnel traffic flow patterns, safety of building occupants, moving of equipment, and other requirements for the particular facility shall be given proper consideration. Where room doors open into corridors, frames should be recessed to prevent the open doors from encroachihg on clear corridor spaces for personnel safety reasons. Greater corridor width may be required for moving large equipment (both initial equipment installation and future replacement or removal), or for ultimate

decontamination and decommissioning of the facility, including equipment required during decontamination. Where equipment is recessed in corridors, such as firehose racks or cabinets, drinking fountains, and pay telephones, it is advantageous to group such equipment to the maximum extent possible.

c. Interior Walls and Partitions.

(1) Interior walls and partitions shall be selected to fulfill the functional use requirements of the facility. Specific materials and applications discussed herein are intended to illustrate functional application and economic types. Concrete block, structural glazed facing tile, or noncombustible drywall construction are commonly used for fixed partitions. Walls should not be plastered except where sanitation or health-physics hazards require such impervious surfaces that cannot be obtained more economically by other finishes. In areas where radiation or other hazardous contamination will occur, suitable washable or strippable paints or suitable liners (e.g., stainless steel) shall be used on walls, floors, and ceilings appropriate for conditions to be encountered. Attachment XVII-2 contains a typical finish schedule, for a recently completed DOE laboratory-office facility, for illustration purposes only. In the planning and design of new laboratory facilities, economy in finishes shall be given particular attention, in keeping with the character of the facility and functional requirements and based on the life-cycle cost concept. For additional criteria on interior finishes, see paragraph 11i in Chapter IV.

(2) Fixed partitions shall be provided for corridors and office space unless movable partitions are functionally and economically justified and adequately satisfy fire-safety, and other health and safety requirements for the particular facility. Movable partitions may be used to separate laboratory modules where the need for future flexibility is justified and all safety requirements are satisfied. Where movable partitions are used, module dimensions shall be selected from commercial stock sizes. Consideration should be given to use of partial height partitions, extending from the top of mutual-use pipe chases for adjacent laboratories to the ceiling or slab above. This approach allows consolidation of pipe runs and flexibility in operations, and can achieve savings in construction costs.

d. Laboratory Furniture.

(1) When specifying furniture for laboratories, standard stock sizes, materials, and finishes of a competitive type shall be selected. To take full advantage of the flexibility of modular arrangement of the work space, base cabinets, bench tops, sinks, and hoods shall have nominal unit lengths which may be interchanged to make up the required combinations. In developing furniture layouts, design

allowances should be made for a filler piece between furniture units equivalent to 1 inch in every 10 feet of laboratory bench to protect against minor variances in vendor unit dimensions and wall material tolerances.

(2) In laboratories handling radioactive materials, the weight of shielding material to be placed on bench tops and hoods shall be taken into account in specifying bases and cabinets. Most commercial bases and cabinets for laboratory use will support 300 to 500 pounds per leg or corner.

(3) Furniture used for purposes requiring more than the general illumination levels to be provided within the laboratories should be so designed and equipped to provide local task lighting of the required intensity.

e. Hoods and Glove Boxes.

(1) Provision shall be made for an adequate number of fume hoods for the conduct of operations producing hazardous air contaminants. Such operations may occur not only in chemistry areas but also in areas assigned to biology, metallurgy, physics, and similar activities. See paragraph 5a, below, for ventilation and exhaust system criteria.

(2) The number, size, materials of construction, and arrangement of hoods and appurtenances shall be based upon operational requirements. The characteristics and operating requirements for hoods also govern how the HVAC system design is integrated. Commercially-available hoods are satisfactory for the needs of the majority of installations and are usually more economical than custom fabrication. Hoods 6 feet wide supported on standard type base cabinets provide adequate work space for most tasks. For special requirements, consideration shall be given to use of designs already developed by several of the DOE national laboratories before proceeding with a new design.

(3) The effects of simultaneous use of hoods within a given laboratory room shall be analyzed in the planning phase, and any problems resolved in the design phase, to preclude noise or other wind-tunnel effects common with high velocity air movement in limited spaces, and to avoid problems in balancing air handling systems after the facility is completed. Where such potential conditions exist, consideration should be given to the use of closed glove box systems. Dry boxes, glove boxes, and other closed systems which require only about 10 percent or less of a conventional hood's air supply have gained wide acceptance for radiochemical work and should be utilized to the maximum extent possible.

(4) Noncombustible materials, resistant to corrosion or contamination, should be specified for the inside surfaces. Stainless steel may be specified if economically competitive or where otherwise required by

the type of contaminants and the specific operations to be performed. Exterior walls may be of standard furniture steel or other noncombustible material. Special consideration shall be given to material selection for hoods and hood effluent air and treatment systems, being designed for operations involving nitric or perchloric acid. Interaction between these acids (and acid mists) and caulking compounds, certain exhaust system materials, and effluents exhausted from other hood systems has proven to be particularly hazardous. See NFPA 45, Chapter 9, "Laboratory Operations and Apparatus," for special requirements in the selection and design of perchloric acid fume hoods, duct work, and exhaust equipment.

(5) For guidance in selecting hood face velocities see paragraph 5a(2), below. Contoured front pillars and a horizontal vane are desirable to reduce turbulence. Normally, fume hoods exhausted upward with shortest possible ducts result in the most economical arrangement. Downdraft hoods shall not be used unless required by the particular situation.

f. Structural Design. All new laboratory buildings or building additions shall be designed in accordance with the criteria in Chapter IV of this Order, and the following criteria:

(1) Laboratories containing plutonium, other radioactive material, or other material that would be likely to produce significant health or safety hazards shall be evaluated as to the degree of risk, and more stringent criteria applied in structural design as necessary.

(2) Many laboratory buildings are subject to future additional ceiling-roof equipment loadings. In planning and designing laboratory buildings consideration shall be given to providing for a future 10 to 20 psf additional structural loading.

(3) Where floor-mounted laboratory equipment will have a commonality of use, it should be centrally located with respect to laboratory operations. Floor loadings and location of equipment, and projections of future additional equipment requirements and their floor loadings, need to be carefully evaluated and provided for in structural planning and design.

5. MECHANICAL. These criteria shall be followed in the design of mechanical components and systems for laboratory facilities, including heating, ventilating and air conditioning, piped services and utilities, and plumbing which includes sanitary and storm drainage as well as other disposal systems.

a. Heating, Ventilating, and Air Conditioning. The design of laboratory HVAC and exhaust systems shall conform to the basic criteria including codes, standards and guides contained in Chapter V of this Order, and the following criteria. Emphasis shall be placed on energy conservation optimization using life cycle cost techniques. For new laboratory buildings, consideration shall be given to providing a computer-controlled data and control center to monitor, reset, and control all systems to optimize energy conservation in laboratory operations.

(1) Supply Systems.

(a) One of the major objectives in the design of supply systems is to ensure that there will be no adverse effects on personnel health and safety. With this objective satisfied, and where economically feasible on a life cycle basis, new laboratories shall be provided with independent air handling systems for laboratory spaces and office spaces. The systems should be energy conservation oriented in design and operation. They should also be compatible with space functional requirements such that they can be shut down when spaces are not occupied. Where feasible from a health, safety, and functional standpoint, air should be recirculated. Common systems should serve only those areas with similar load characteristics. Interior and exterior zones should not be served by the same system in order to minimize the need for reheat devices.

(b) As an energy conservation feature, individual laboratory fan-coil chilled water units sized for the variable interior process load shall be considered in lieu of the standard reheat coil configuration. For multi-laboratory configurations this would mean that a central fan supply system would be designed for normal working conditions, while the room fan-coil units would provide additional cooling to match the variable interior process load.

(c) Air distribution systems shall be designed with air flowing from clean to progressively dirtier areas, e.g., from personnel corridor - to the laboratory - to fume hood exhaust. In this manner, the clean area will always have a higher air pressure than the adjoining dirty area to assist in preventing backflow of contaminated air.

(d) Generally, for usual laboratory needs, standard aspirating and non-aspirating types of ceiling diffusers are adequate to maintain acceptable air velocities at laboratory bench level. The use of perforated pan-type, suspended ceilings should be considered where the air change rate requirements are greater than 20 to 30 per hour, or for laminar flow laboratories; but should not be used where cleanliness is a requirement.

(2) Ventilation and Exhaust Systems.

(a) Since the operation of fume hoods in a laboratory building normally requires greater quantities of make-up air than are normally required for ventilation purposes, make-up air quantities should be calculated on the basis of the number of fume hoods required for operations producing hazardous fumes. A diversity factor should be utilized as appropriate in the design calculations but the minimum quantity of make-up air required should not be less than that required for one hood. For guidance in the selection of hood face velocities, see ACGIH "Industrial Ventilation: A Manual of Recommended Practice"; NFPA-45, Chapter 6, Ventilation Systems"; and ORNL/TM-6400, Minimum Acceptable Face Velocities of Laboratory Fume Hoods and Guidelines for Their Classification."

(b) External auxiliary-air type fume hoods shall normally be used to reduce the laboratory heating and cooling energy consumption unless functionally unsuitable or not economically justified. However, external auxiliary-air type laboratory fume hoods should not be used to control very toxic (probable lethal dose-human, 50-500 mg/Kg) materials or radioactive materials. Where auxiliary-air type hoods are used, the auxiliary air should be supplied outside the hood proper, directly above the hood face or peripherally such as to best assure maintenance of a uniform design air velocity through the face opening and to thereby achieve the required degree of operational safety. The supplemental air supply would be tempered during the heating season with no temperature control during the summer or cooling season. A minimum of 30 percent of hood exhaust shall normally be supplied from the laboratory with the remaining supplied by the auxiliary air supply system. Use of the auxiliary system greatly reduces the conditioned supply air rate to a laboratory. See ASHRAE Applications Handbook, "Laboratories" chapter for more specific design data. Consideration should be given to a variable-volume system in conjunction with the hood on-off controls, to minimize the consumption of energy; but only where there will be no adverse effects on personnel health and safety. Glove boxes and other closed systems shall be utilized to the greatest extent practicable.

(c) Heat recovery systems shall be evaluated for all laboratory hood exhaust systems. The coil "run-around cycle" is particularly adaptable because of the remote exhaust and intake air openings and the closed loop heat transfer media that prevents cross-contamination of air streams.

(d) Central exhaust systems for a number of laboratory rooms shall be considered, to facilitate heat recovery, unless special operations or health and safety requirements dictate otherwise. To meet applicable Federal regulations, such as OSHA, or other regulations or where cross-contamination or fire spread is a possibility, independent exhaust systems may need to be provided. Fire dampers should be considered at strategic locations in all multi-hood, multi-laboratory room systems, and fire sprinklers shall be located in ducts conveying combustible materials or housing charcoal filters.

(e) Seams and joints in fume hoods and fume exhaust ductwork shall be sufficiently tight to prevent leakage. Selections of exhaust system materials and location of filter banks and fans shall be based on the characteristics of the gases or materials handled and the potential spread or release of contaminated materials. Highly corrosive chemicals, strong oxidizing acids (especially perchloric acid), pyrophoric, toxic, or other hazardous materials shall be handled in systems equipped with washdown features. Minimizing contamination of the exhaust duct system is of particular importance in the handling of radioactive and other hazardous contaminants, and proper consideration shall be given to locating filters as close to the source of contamination as practicable (e.g., at the hood discharge).

(f) Consideration shall be given to the use of chemical scrubbers to mitigate or eliminate effluents which may be toxic, or objectionable because of odor or visibility.

(g) Where continuous operation of the exhaust system is necessary for health, safety, or operational reasons, an emergency power source shall be provided, with automatic transfer upon loss of normal power.

(h) Air intakes and exhausts shall be located to prevent recirculation of contaminated exhaust air. At a minimum, the design of stacks and discharge ducts shall follow the guidelines set forth in the ASHRAE Fundamentals Handbook, "Air Flow Around Buildings" chapter. Consideration shall be given to the immediate areas as well as the total environment. Building HVAC air intakes, surrounding structures, other activities in the area, normal weather conditions (fog, rain, prevailing winds), abnormal natural phenomena risks, velocity at discharge, and material being discharged to the atmosphere shall govern the size, height, and location of exhaust stacks and discharge ducts.

(i) Controls and alarms shall be interlocked to maintain the required air balance between hood interiors and the room. Visual and/or audible alarms shall be provided to indicate malfunction of either the hood supply or exhaust air system. Consideration shall be given to connecting all supply and exhaust fans into a master fan shutdown system.

(j) Where the capability for laboratory hood shutdown or partial shutdown, during periods of non-use, is determined to be feasible and will not adversely affect personnel health and safety, an operating indicator such as a pilot light (or other type of indicator) should be provided to let the operator or other building personnel know the ventilation system status. Such indicators should be located in each laboratory, the adjacent corridor, and at the central monitoring and control location, where such capability exists.

(k) Criteria for air cleaning systems (filtration) are contained in paragraph 9d, Chapter V of this Order.

b. <u>Service Piping</u>.

(1) Laboratory services usually consist of appropriate combinations of hot and cold water, burner gas, compressed air, vacuum, distilled or demineralized water, drains, and so forth. Small quantities of special gases are normally provided in portable cylinders. Each service shall be based on operating requirements, with allowance for future-use connections. Shutoff valves shall be provided in each branch line at the service header, and in each module of laboratory work space. Floor drains in laboratory areas shall be provided as required for the operations to be performed.

(2) Potable water systems shall be protected from contamination from any source by the use of air gaps, vacuum breakers, or approved backflow prevention devices.

(3) Centralized vacuum systems shall not be used wherever there is a possibility of spreading contamination from radioactive, toxic, or bacterial sources, unless the centralized vacuum system exhaust has the same level of filtration as the exhaust ventilation filtration provided for the most highly contaminated work station.

(4) Each piping service shall be identified by a coding system that is consistent with other similar buildings on the site.

(5) Safety showers and eyewash fountains shall be provided where hazardous chemicals or other hazardous materials constitute a danger to personnel. Safety showers and eyewash fountains shall conform with OSHA regulations in 29 CFR part 1910, with lights or signs installed indicating their location. Floor drains shall be provided in the immediate vicinity of safety showers; except that floor drains shall not be provided for eye or deluge showers in laboratories where nuclear criticality is a consideration.

c. <u>Special Piping and Drainage Requirements</u>. In addition to the usual sanitary and storm sewer systems, other drain systems will often be required for chemical wastes, toxic materials, high temperature solutions, radioactive wastes, or dangerous bacteriological solutions. All special laboratory drain systems shall be carefully analyzed and designed to protect all building occupants and the public during normal operations and abnormal conditions. Laboratory floor drains should be adequately trapped to avoid cross-contamination, and consideration should be given to providing holding tanks to avoid indiscriminate spill to sanitary sewer systems.

Venting of drain systems shall be given special attention, and suitable alternates to normal atmospheric venting adopted where the hazards of the waste materials and off-gases dictate. All-welded pipe systems should be utilized to minimize joint leakage of toxic materials. Piping containing hazardous solutions or gases should not be buried or concealed unless alarm systems, leak detectors, and means for secondary containment are provided.

6. ELECTRICAL AND TELECOMMUNICATIONS. In addition to the criteria contained in Chapter VI and Chapter VII of the Order, the following criteria shall also be applied in the planning and design of laboratory facilities.

   a. Special attention shall be given in the planning and design of electrical distribution systems in laboratory facilities to assure the needed degree of flexibility for laboratory and experimental work and for personal safety. Receptacles shall be located with due consideration to the location of laboratory benches, fixed and movable equipment, and work areas. Where practicable, receptacle strips should be utilized. Except for standard convenience receptacles (e.g., 110-volt, single phase), all receptacles should be clearly marked as to voltage, number of phases of power supply, conventional building power or "clean power" (e.g., isolated power supplies from constant voltage sources), whether alternating current or direct current, conventional 60 Hz or other alternating current frequencies, and so forth. Particular attention shall be given to electrical safety requirements, and DOE/EV-0051/1, "Electrical Safety Criteria for Research and Development Activities" (Interim Criteria of August, 1979) shall be utilized in laboratory facility planning and design to the extent applicable. In addition, it must be recognized that special electrical shock and burn hazards can exist in most types of laboratories from such sources as unique experimental apparatus, laboratory instruments, test equipment, and those hazards common to wet laboratories. Proper considerations shall be given to the use of ground fault circuit interrupter (GFCI) devices. See paragraph 8, Chapter VI of this Order for additional personnel protection criteria.

   b. Emergency lighting shall be provided where specifically required by the operations to be performed and where otherwise required for life safety. These shall be either self-contained emergency lighting units or selected lighting fixtures that can be served from an emergency power source on loss of normal power source. When self-contained emergency lighting units are installed in an area, the source of AC power shall be taken from the same circuit as the area lighting but ahead of the lighting switch station, or from the area security light fixture(s) continuous power source that is not switched.

   c. Interior telecommunications, alarm and annunicator systems shall be provided for fire alarm, evacuation alarm, radiation alarm, intrusion alarm (as appropriate), paging, public address, or other requirements for the particular facility. See Chapter VII of this Order for additional criteria. Fan shutdown, smoke control, exhaust fan failure, laboratory power "scram," individual laboratory products-of-combustion, and other detection and alarm systems shall be provided as required for personnel, facility, and public safety purposes. Alarm systems shall be designed, installed, and tested to assure that alarm devices can be seen or heard in the ambient conditions of the area they are intended to cover.

d. Design of interior and exterior lighting systems shall be in accordance with criteria in Chapters VI and VIII of this Order.

e. Emergency power system design shall be in accordance with criteria in Chapter VI of this Order.

f. Isolated ground systems (e.g., signal ground systems) may be required to meet special laboratory instrumentation or other laboratory equipment needs. Such separate ground system shall be clearly identified and protected against improper usage.

7. FIRE PROTECTION. Basic fire protection criteria to be followed in the planning and design of laboratory facilities are contained in Chapter X of this Order. National Fire Protection Association (NFPA) codes and standards that are specifically identified in paragraph 2a, of this Chapter shall also be followed, when applicable. Fire resistive or noncombustible materials shall be specified for the building proper. Laboratory benches, cabinets, and hoods should be constructed of noncombustible materials. If combustible materials are necessary, treatment with a fire retardant shall be required to reduce the risk of fire to a satisfactory level. Automatic sprinklers shall be provided in accordance with requirements in Chapter X of this Order. Filter plenums shall be so located, or suitable protection means provided, to prevent high efficiency particulate air (HEPA) filters from being exposed to temperatures in excess of their ratings due to a fire at the laboratory fume hood or glove box. In those cases where mixed fire and radiation risks are present, automatic sprinklers or equivalent automatic fire suppression systems shall be provided.

8. ENVIRONMENTAL PROTECTION. At an early stage of project planning or design, laboratory processes shall be reviewed and potentials for environmental pollution analyzed, an environmental assessment prepared (i.e., "Action Description Memorandum" per the DOE "Environmental Compliance Guide)", and the need for an environmental statement ascertained. See paragraph 3d in Chapter I of this Order.

9. HEALTH AND SAFETY. See paragraph 3b in Chapter I of this Order for applicable criteria, including safety analysis requirements.

10. SAFEGUARDS AND SECURITY. See paragraph 3c in Chapter I of this Order for applicable criteria.

11. QUALITY ASSURANCE. A quality assurance (QA) program shall be developed and implemented for laboratory facility projects in accordance with paragraph 3f, in Chapter I of this Order.

12. ACCESSIBILITY AND USABILITY BY THE PHYSICALLY HANDICAPPED. See paragraph 13 in Chapter IV of this Order.

## TYPICAL LABORATORY LAYOUTS

1. The sketches in the Figures 1 through 4, following Table 1 in this Attachment, illustrate two of the more common laboratory room layouts used in laboratory facilities for chemical, biological, and environmental research.

   Figure 1 (PLAN "A") -- illustrates a 2-person laboratory room layout that contains immediately adjacent office space for one researcher. Additional office space is provided elsewhere within the facility for the other researcher.

   Figure 2 (PLAN "B") -- illustrates a 2-person laboratory room layout, where office space for the two researchers is located elsewhere in the facility.

   NOTE: For illustration purposes, Figures 1 and 2 have been drawn utilizing a 20-foot wide module, but either plan may be adaptable for other module widths.

   Figure 3 -- illustrates the advantages inherent in arranging laboratory rooms (typical PLAN "B" laboratories) in a back-to-back and adjacent configuration. Such arrangement minimizes the extent of service piping runs, while providing for ease of maintenance. Offices for research personnel are shown across the corridor from each laboratory room.

2. The choice of plans, and to some extent the modular size, should reflect the initial needs of the intended users, but should also provide for potential future needs. It should be recognized that some laboratory operations may require sizable floor-mounted equipment within the laboratory rooms. Where this is the case, it is preferable to supplant wall or center table bench units, plus increasing the modular width if necessary, rather than encroach on the working aisle space. The laboratory rooms should not be sized to accommodate floor-mounted equipment within the working aisles, particularly when retaining bench units in place. This can often lead to inefficient use of space (e.g., oversizing aisle space to accommodate pieces of floor-mounted equipment), and can be hazardous to laboratory personnel during normal operation and emergency egress situations.

3. As stated in paragaph 4b(2) of this Chapter, suggested laboratory unit sizes are 10 or 20 feet by 20 feet, 10 or 20 feet by 24 feet, and 12 or 24 feet by 24 feet. However, this should not be construed to mean that other modular sizes are unacceptable. For example, an 11 footwide module has proven more efficient for some wet chemistry operations in the petroleum industry, and a 19 foot-wide by 25 foot-long modular size has been found generally most efficient by companies in the petrochemical industry. The latter utilizes a common terne plate-covered pipe rack between wall benches, with a channel-mounted fire partition extending from the top of the bench unit splash-back to

the underside of the floor slab above. This is illustrated in Figure 4. This approach has several advantages:

a. it can reduce total laboratory building area by as much as 5 percent per floor;

b. a common pipe rack is used, thereby eliminating the need for multiple through-wall penetrations, and

c. it provides flexibility in laboratory room subdivision (or expansion) with minimal impact on operations. This can be desirable in biological lab spaces where experimental needs often dictate rearrangement of space during the life of the facility. The identification, herein, of some of the different module sizes and associated features is not for the purposes of dictating what module sizes or laboratory features are to be selected and used. Selections need to be made after careful attention has been given to facility space planning, properly considering the initial facility cost, flexibility of laboratory space needs to meet changing requirements, and ease of maintaining, revising, or extending laboratory utility services.

4. With few exceptions, laboratory operations involve the use of hazardous materials. For this reason, a secondary (emergency) exit will usually be required. This is illustrated in Figures 2 and 3 opening into the service corridor; and in Figure 1 opening into the office space, and on into the corridor. Should the service corridor be designated for storage of cylinder gases, the secondary exit should be into the adjacent laboratory room.

5. Table 1, illustrates the basic differences in effective laboratory bench space, and the comparative relationships in bench space vs. gross laboratory and office area (assuming two offices per lab in all cases) among the various laboratory arrangements (module sizes) in the PLAN "A" and PLAN "B" configurations. The identification of two offices per lab module and the approximate sizes of these offices, as used herein, are for illustration purposes. The actual office requirements for laboratory personnel will need to be determined on a case-by-case basis.

Table 1

| Laboratory Module Size | Max. Effective Bench Space (lin. ft.) | Gross Area 1/ Lab + Offices (sq. ft.) | % Increase in Gross Area over Plan A-1 | % Increase in Effective Bench Space over Plan A-1 |
|---|---|---|---|---|
| PLAN "A" 2/ | | | | |
| A-1 20' x 20' | 42 3/ | 708 | -- | -- |
| A-2 20' x 24' | 61 | 788 | 11 | 45 |
| A-3 24' x 24' | 65 | 920 | 30 | 55 |

Table 1 (Cont.)

| Laboratory Module Size | Max. Effective Bench Space (lin. ft.) | Gross Area 1/ Lab + Offices (sq. ft.) | % Increase in Gross Area over Plan A-1 | % Increase in Effective Bench Space over Plan A-1 |
|---|---|---|---|---|
| PLAN "B" 4/ | | | | |
| B-1 20' x 20' | 68 | 877 | 24 | 62 |
| B-2 20' x 24' | 84 | 957 | 35 | 100 |
| B-3 24' x 24' | 88 | 1,096 | 55 | 110 |
| B-4 19' x 25' | 88 | 928 | 31 | 110 |

1/ Gross Areas include 8-inch exterior wall thickness allowances (see Figure 3).

2/ PLAN "A" includes one office adjacent to the laboratory (see Figure 1), and a second office elsewhere in the facility. Gross area allowance for this second office is included in the total Gross Area (Lab + Offices) shown in this Table.

3/ Requires rotating office layout by $90^{0}$ from that shown in Figure 1.

4/ PLAN "B" assumes two offices elsewhere in the facility (see Figure 3). Gross area allowances for these two offices are included in the total Gross Area (Lab + Offices) shown in this Table.

6. Using PLAN A-1 as a common baseline, a comparison of the difference in increase in percentiles of effective bench space vs. increase in percentiles of gross area reveals the 19' x 25' module is the most efficient where two offices per lab are required (i.e., 110 percent increase in effective bench space with only a 31 percent increase in total gross area). Comparison of PLAN B-1 with PLAN A-1 reveals that PLAN B-1 requires 24 percent more gross area taking into account the "gross area requirements" for offices located elsewhere. However, the effective bench space is 62 percent greater than PLAN A-1. The data in Table 1, above, illustrate the types of tradeoffs that need to be evaluated when selecting among alternate laboratory module configurations and sizes together with alternate methods of providing office spaces for laboratory researchers.

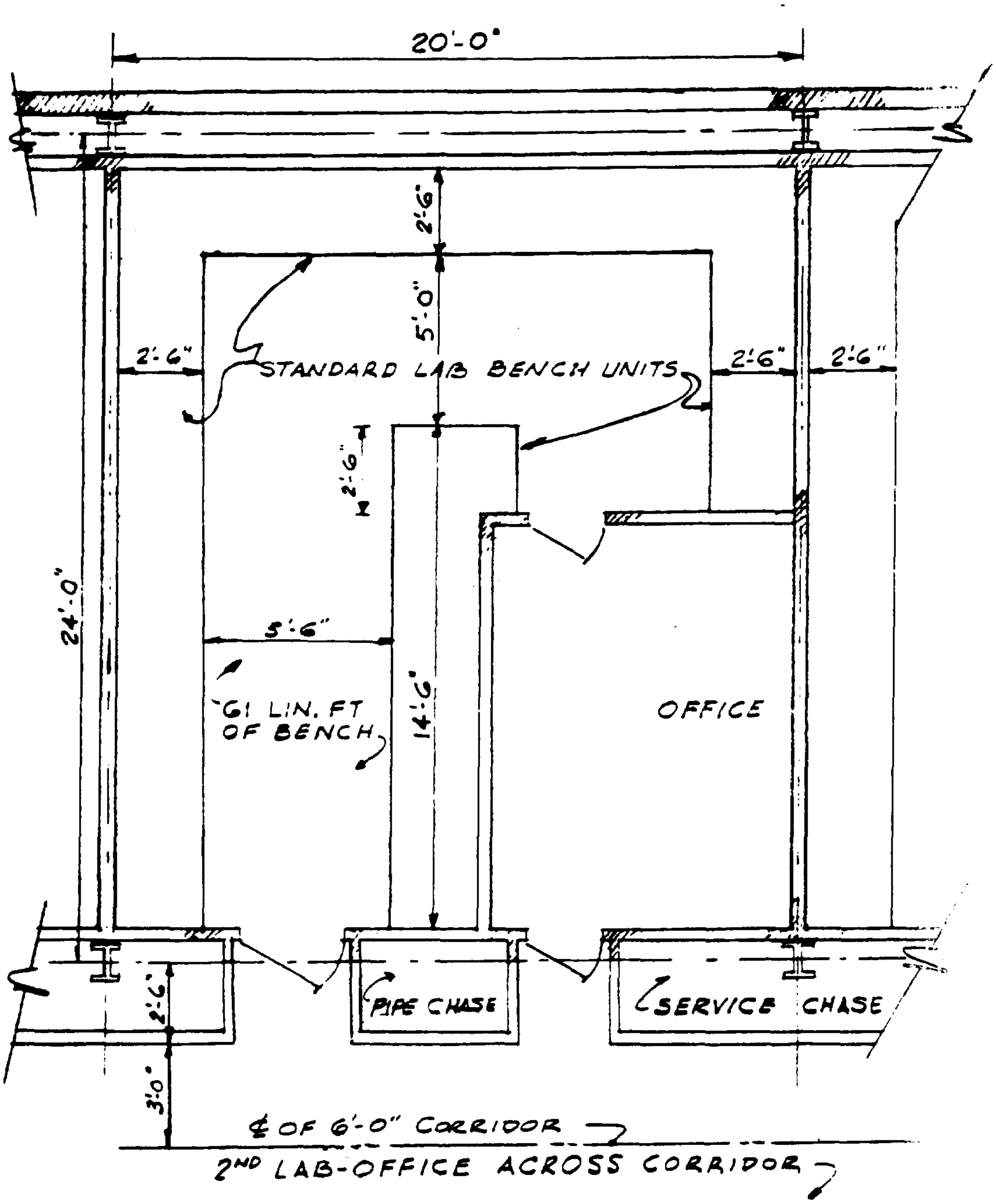


Figure 1

Typical Laboratory Layout - PLAN "A"

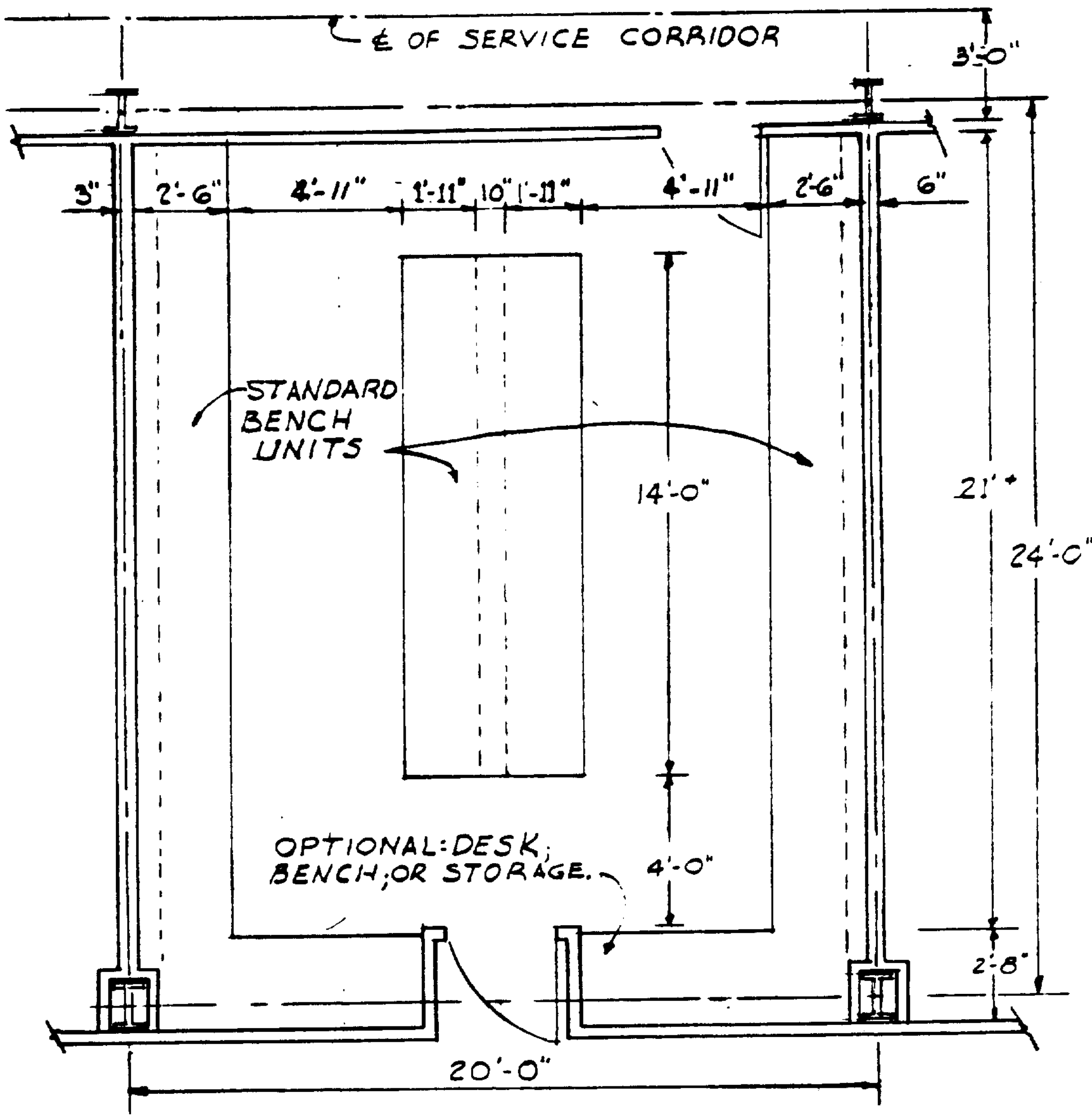


Figure 2

Typical Laboratory Layout - PLAN "B"

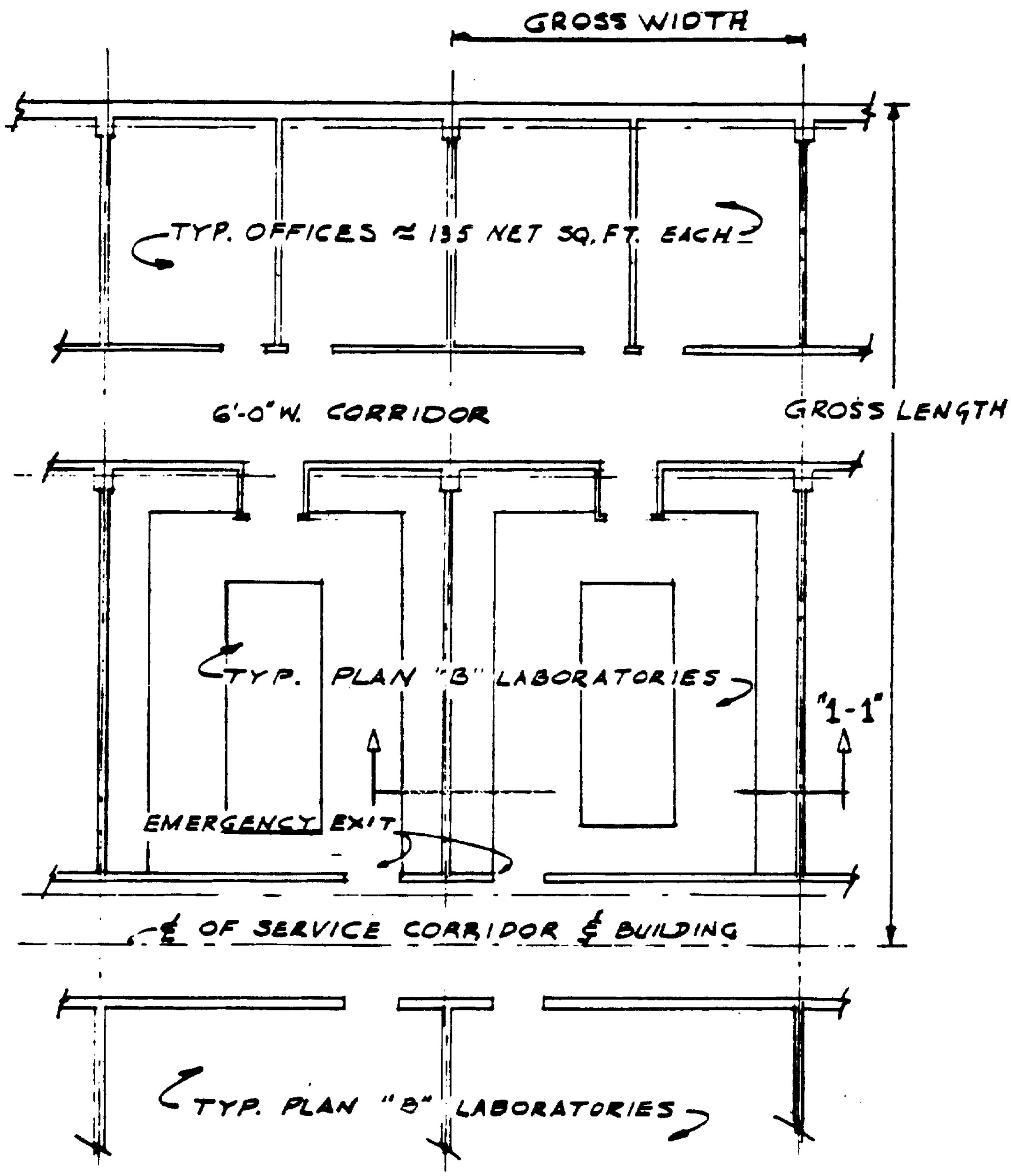


Figure 3

Arrangement of PLAN "B" Laboratories and Offices

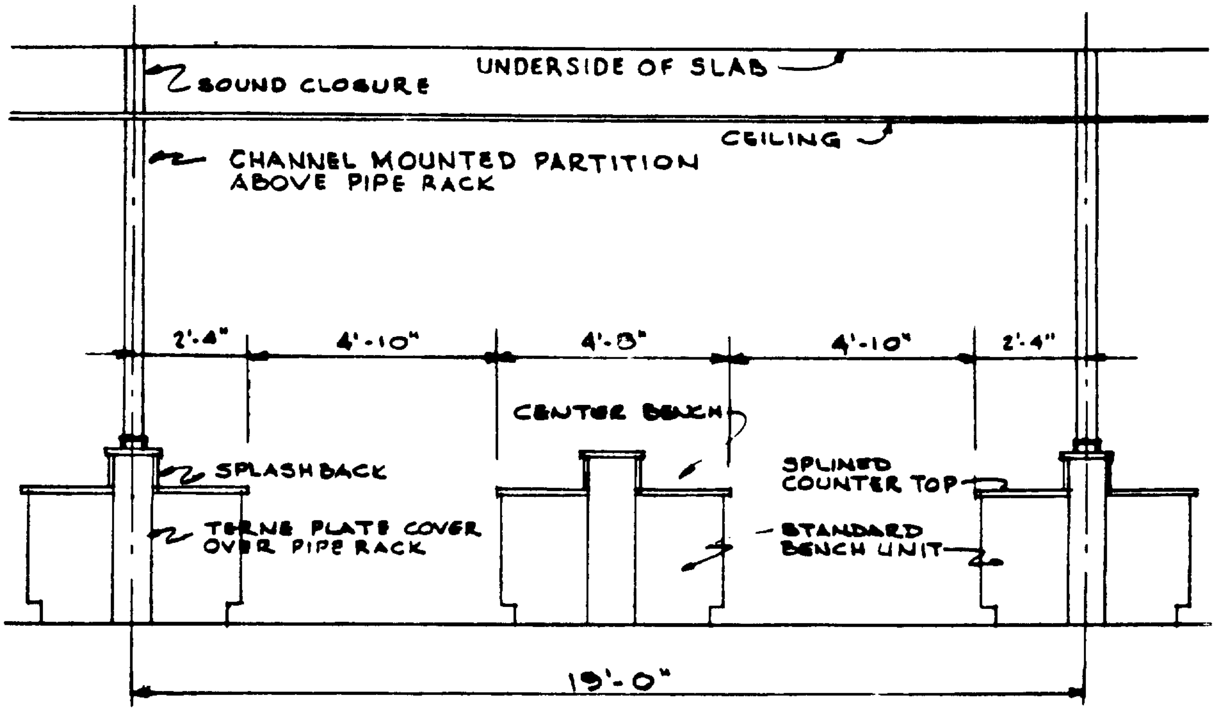


Figure 4

Section "1-1" on Figure 3, for a Module Width of 19 Feet

## TYPICAL FINISH SCHEDULE[1/]

| SPACE | FLOOR FINISH | FLOOR BASE | WALL MAT'L | WALL FINISH | CEILING |
|---|---|---|---|---|---|
| AUDITORIUM | VAT & CARPET | CB | CMU | PAINT | SATC |
| CANTEEN | VAT | CB | CMU | PAINT | SATC |
| COMPUTER BATCH STA | VAT | - | CMU | PAINT | SATC |
| CONFERENCE RM | VAT | CB | CMU | PAINT | SATC |
| CORRIDOR | VAT | CB | CMU | PAINT | SATC |
| DARK ROOM | VAT | CB | CMU | PAINT | SATC |
| ELEVATOR SHAFT | - | - | - | - | - |
| JANITORS CLOSET | VAT | CB | CMU | PAINT | EXPOSED |
| KEY PUNCH | VAT | CB | CMU | PAINT | SATC |
| LABORATORY | VAT | CB | COHC | PAINT | EXPOSED |
| LIBRARY | VAT | CB | COCH & CMU | PAINT | SATC |
| LOBBY | VAT | CB | CMU | PAINT | SATC |
| MECH-ELECT EQUIP | HDNR | - | CMU | PAINT | EXPOSED |
| OFFICE | VAT | CB | COCH & CMU | PAINT | SATC |
| PENTHOUSE | HDNR | - | CMU | UC | EXPOSED |
| PROJECTION | VAT | CB | CMU | PAINT | SATC |
| RECEPTION | VAT | CB | CMU | PAINT | SATC |
| SHOP | HDNR | - | CMU | PAINT | EXPOSED |
| SHOWER & DRYING RM | UC | UC | CMU | UC | SATC |
| STAIR | HDNR | - | COCH & CMU | PAINT | EXPOSED |
| STERILIZER RM | UC | UC | CMU | UC | SATC |
| STORAGE | VAT | CB | CMU | PAINT | EXPOSED |
| TELEPHONE CLOSET | HDNR | - | CMU | PAINT | EXPOSED |
| TOILET | UC | UC | CMU | UC | SATC |
| UTILITY CHASE | HDNR | - | CMU | PAINT | EXPOSED |
| VESTIBULE | VAT | CB | COCH & CMU | PAINT | EXPOSED |
| WOMENS LOUNGE | UC | UC | CMU | UC | SATC |

LEGEND

CB - COVE BASE
COCH - CONCRETE
CMU - CONCRETE MASONRY UNITS
HDNR - HARDENER
SATC - SUSPENDED ACOUSTIC TILE CEILING
UC - URETHANE COATING
VAT - VINYL ASBESTOS TILE

1/ For a recently completed laboratory/office facility.

# CHAPTER XIX

(RESERVED)

(MAINTENANCE AND REPAIR SHOPS)

To be issued

# CHAPTER XVIII

(RESERVED)

(WAREHOUSE AND OTHER STORAGE BUILDINGS)

To be issued